C 51.17/12:989/7

# Tech Notes

July 1989

PB89-925907

NTIS

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Center for the Utilization of Federal Technology

ALSO DESCRIBES 90 FEDERAL TECHNICAL INFORMATION CENTERS

# NOW! Work Directly with Government Labs and Engineering Facilities

"The Directory should be popular in research and business libraries"

—Reference Book Bulletin
American Libraries Association

**Find them easily in the Directory of Federal Laboratory & Technology Resources.** This valuable directory will guide you to hundreds of Federal agencies, laboratories, and engineering centers willing to share their expertise, equipment, facilities, and special services to aid your research and engineering efforts. Detailed summaries of these unique resources are arranged in 32 subject-oriented areas for easy reference. Descriptions of 90 Technical Information Centers are included.

These centers offer information services and expertise in areas such as fuels, cold regions, concrete, fisheries, toxicology, pesticides, plastics, and much more.

**The NAME, ADDRESS, PHONE NUMBER OF A PERSONAL CONTACT IS LISTED FOR EACH RESOURCE!**

**Help is available in 32 technical areas including:**

Aeronautics (31)* • Agriculture & Food (120) • Biological Sciences (68) • Building Technology (20) • Computer Technology (15) • Electrotechnology (43) • Energy (77) • Engineering (86) • Environmental Sciences (67) • Manufacturing (19) • Materials (61) • Medicine (112) • Nuclear (128) • Ocean Sciences & Technology (36) • Physical Sciences (110) • Transportation (14) • Plus others

*number of summaries

Four handy indexes make it easy to locate the resource you need.

1. Subject Term Index
Identifies resources in your technical interest areas.

2. State Index
Find all the resources in your State.

3. Resource Name Index
Look up any resource by name of laboratory or program.

4. Agency Index
Lists resources by agency and State.

All listed resources offer unique capabilities (not readily duplicated in the private sector) to encourage greater use of Federal technology.

**To increase your awareness of hundreds of Federal Technology Resources available to work with you on your projects, order your DIRECTORY now!**

ASK FOR:
PB88-100011/AAW

**DIRECTORY OF FEDERAL LABORATORY AND TECHNOLOGY RESOURCES**

CALL: (703) 487-4650

WRITE:

NTIS Springfield, VA 22161

Enclose check to NTIS for $36 plus $3 for shipping and handling or
Charge to: NTIS Deposit Account, American Express, VISA, or MasterCard.
Please furnish card number, expiration date, signature, and complete mailing address.

# Tech Notes

Highlighting Selected U.S. Government Technology & Resources

**July 1989**

## Contents


**Agriculture & Food** 515

**Computers** 520

**Electrotechnology** 526

**Energy** 546

**Engineering** 551

**Environmental Science & Technology** 566

**Manufacturing, Machinery & Tools** 570

**Materials** 581

**Medicine & Biology** 594

**Natural Resources Technology & Engineering** 605

**Physical Sciences** 607

**Transportation & Components** 615



PENNSYLVANIA STATE UNIVERSITY

JUL 19 1989

DOCUMENTS COLLECTION
U.S. Depository Copy



Published monthly by the National Technical Information Service (NTIS), Tech Notes bring together individual one- to two-page fact sheets prepared by Federal agencies, their laboratories, or contractors. These fact sheets highlight current Federal technology determined to have commercial or practical application. Topics cover new processes, materials, techniques, software, instrumentation, and resources.

Some of the current sources are the Department of the Navy, Department of the Army, NASA, Department of Energy, Environmental Protection Agency, Department of the Interior, and the Department of Agriculture.

Special assistance is provided by the Federal Laboratory Consortium.

Change of address or questions concerning subscriptions should be sent to:
Subscriptions Department
National Technical Information Service
Springfield, VA 22161
(703) 487-4630

Suggestions, comments, or questions concerning Tech Notes should be directed to:
Tech Notes Editor
Room 300B F
National Technical Information Service
Springfield, VA 22161
(703) 487-4805

## How to Use Tech Notes

Every Tech Notes fact sheet lists a source for additional information. The source of this information may be a special support package from the originating agency, a personal contact, a licensing opportunity, or a backup report available from NTIS.

Each fact sheet also is perforated to allow for easy removal for those subscribers who may wish to keep a special fact sheet file or route to others in their organization

## Sources of Further Backup Information

Below are two representative examples of how each Tech Note fact sheet provides you with a source of further information. In most cases, this information is provided directly by the agency or its laboratory.

However, there are cases where NTIS is the source for backup documentation. In these cases, use the order form at the end.

### Examples:

significant distance from the endwalls. Therefore, a radial variation in efficiency should be used when designing small stators.
Project Officer Jeffrey E. Haas
(216) 433-4000.

**FOR ADDITIONAL INFORMATION**

You can learn more about this technology by ordering the NTIS report(s):
Cold-Air Performance of Compressor Drive Turbine
Order number: AD-A101066/NAA
Price code: A02
Order from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

158

- Agency contact who can supplement the information contained in the backup report.
- NTIS Order Number*
- NTIS Price Code*
- * See the order form and price code table at the end of the issue.

Suggested applications include other kinds of refrigerators, heat engines, thermal instrumentation, and heat switches.
This work was done by Emanuel Tward of Caltech for NASA's Jet Propulsion Laboratory.
NPO-15479/TN

**FOR ADDITIONAL INFORMATION**
*Contact: Director, Technology Transfer Division, P.O. Box 8587, BWI Airport, MD 21240: (301) 621-0100 Ext.241.*
*REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE*

178

- Agency reference number
- Source of more information about the technology described in the fact sheet
- Page number

# Tech Notes Title List for July 1989

## Agriculture & Food

0515 Floating Raceways Developed for Salmon Culture
0516 Fruit Flies Can't Take the Hot Air
0517 Innovation in Foods: Safety First
0519 Warmed-Over Flavor in Food Delayed by Proteins (Licensing Opportunity)

## Computers

0520 The Strategic Defense Initiative Technology Applications Information System
0521 Navy Experimenting with Computerized Executive Networking Survey System (CENSUS)
0522 OPSMOP: Parallel Symbol-Matching Coprocessor for Rule-Processing Systems

*Software*

0524 Eliminating Tracking System Clock Errors—Problems of redundancy and correlation are avoided.
0525 Stellar Inertial Navigation Workstation—Software and hardware are assembled to support specific engineering activities.

*Other Items of Interest*

0528 Acoustic Regenerator (Licensing Opportunity)
0530 Ultimate Low-Loss Electro-Optical Cable (Licensing Opportunity)

## Electrotechnology

0526 New Calibration Services Offered
0527 Narrow Spectral Bandwidth, UV Solar Blind Detector (Licensing Opportunity)
0528 Acoustic Regenerator (Licensing Opportunity)
0530 Ultimate Low-Loss Electro-Optical Cable (Licensing Opportunity)
0532 BIN Diode for Submillimeter Wavelengths—Uses would include mixers and harmonic generators in receivers for atmospheric and space spectroscopy. (Licensing Opportunity)
0534 Compression of Data in Imaging Radar Polarimetry—The number of data is reduced by a factor of 12.8.
0536 Hybrid Infrared Imager—An experimental device has low noise and high uniformity.
0537 Improved Method for Making Infrared Imagers—Properties of a thin dielectric layer are adjusted precisely.
0538 Microwave Comb Generator—Stable reference tones aid the testing and calibration of microwave receivers.
0540 Automatic Frequency Control for DMSK Receiver—Performance is analyzed theoretically and experimentally. (Licensing Opportunity)
0541 Power-Supply-Conditioning Circuit—Fluctuations of voltage are suppressed in power supplies for precise radio-frequency circuits. (Licensing Opportunity)
0542 Optimal Placement of Multiple Antennas—Obscuration by the structure or vehicle is taken into account.

*Testing & Instrumentation*

0544 Capacitive Displacement Sensor with Frequency Readout—The frequency varies approximately linearly with displacement.
0545 Low-Power Magnetic Current Sensor—Direct current is sensed via a saturable-core reactor.

*Other Items of Interest*

0548 Stable, Efficient Thin Film Solar Cell Developed

## Energy

0546 Improved Planning Methods for Electric Utilities
0548 Stable, Efficient Thin Film Solar Cell Developed
0549 Endurance Tests of Amorphous-Silicon Photovoltaic Modules—Failure mechanisms in high-power service are studied.

*Testing & Instrumentation*

0550 New Apparatus Measures Insulation Conductivity

## Engineering

0551 Reliability Engineer's Toolkit
0552 R, M & S Standards Primer: Guidelines for DOD Reliability, Maintenance, and Safety Standards
0553 Relief Valve for Superconducting Magnets
0554 Method Developed for Curing Patches on Contoured Surfaces
0555 Extension for Abrasive-Jet Cleaning—Hard-to-reach places can be cleaned more easily. (Licensing Opportunity)
0556 Modeling Plants with Moving-Average Outputs—Three discrete-state-variable representations are derived.
0557 Numerical Solution of Navier-Stokes Equations—Three-dimensional, incompressible flow is simulated on a computer.
0558 Plating Patches on Heat-Exchanger Jackets—Permanent repairs are made without welding. (Licensing Opportunity)
0559 Shock-Induced Heating in a Rocket Engine—Misalignment can give rise to hotspots on walls.
0560 Tethered Remote Manipulator—Potential advantages include safety and long reach. (Licensing Opportunity)
0561 Two-Thumbed Robot Hand—A middle finger and two thumbs would grasp and sense the shapes of a variety of objects. (Licensing Opportunity)

## Engineering (Cont.)

*Testing & Instrumentation*

0562 Turbulence within the Walls

0563 Constructing R-Curves from Residual-Strength Data—Old data can be exploited in a new concept.

0564 Fiber-Optic Sensor Would Detect Movements of Shaft—Magnetic inserts are not required.

0565 Detecting Residues on Grit-Blasted Surfaces—Fluorescent or iridescent additive would reveal unwanted deposits. (Licensing Opportunity)

*Other Items of Interest*

0550 New Apparatus Measures Insulation Conductivity

0566 Grout Fixation of Variable Phosphate/Sulfate Waste

0578 Better Sheet Metal Products with Less Waste

0615 Evaluation of Railroad Tracks

## Environmental Science & Technology

0566 Grout Fixation of Variable Phosphate/Sulfate Waste

*Testing & Instrumentation*

0568 Development of a High Volume Surface Sampler for Pesticides in Floor Dust

*Other Items of Interest*

0583 New Material Aimed at Measuring Workplace Dust

## Manufacturing, Machinery & Tools

0570 Abrasive Waterjet Cutting

0572 Evaluation of Explosion Welding for Repairing Aluminum Structures

0574 Hyper-Standard has Applications for PDES

0575 Generation Method Improves Spiral Bevel Gears—Conjugate tooth surfaces reduce kinematic errors.

0576 Making and Inspecting Large Wire Grids—Old techniques are refined and combined to make new polarizers

0577 New Methods for Generating Gear Surfaces—Conjugate surfaces can be generated and analyzed for a variety of useful configurations.

*Testing & Instrumentation*

0578 Better Sheet Metal Products with Less Waste

0579 Plug Would Collimate X Rays—A simple device would create a narrow, well-defined beam for radiographic measurements of thickness.

0580 Three-Dimensional Coaxial Weld Monitoring—Parallax would be incorporated into the optical system.

*Other Items of Interest*

0558 Plating Patches on Heat-Exchanger Jackets—Permanent repairs are made without welding. (Licensing Opportunity)

0588 Canning of Powered Metal for Hot Isostatic Pressing—The quality of the specimen is enhanced by and improved canning process. (Licensing Opportunity)

## Materials

0581 Grain Coarsening Associated with Thermal Fatigue in Solder Contacts

0583 New Material Aimed at Measuring Workplace Dust

0584 Titanium Oxide-Dispersion Alloys Prepared by Rapid Solidification

0585 Toughened Ceramics Shown to Exhibit Sensitivity to Fatigue

0587 Acetylene-Terminated Aspartimides and Derived Resins—New polymers and derived blends exhibit improved processability and properties. (Licensing Opportunity)

0588 Canning of Powered Metal for Hot Isostatic Pressing—The quality of the specimen is enhanced by and improved canning process. (Licensing Opportunity)

0589 Functional Microspheres—Tiny beads develop from an aqueous solution. (Licensing Opportunity)

0590 Making Single Crystals of $B_4C$—Crystals precipitate from solution in copper.

0591 Improving Thermoelectric Properties of (Si/Ge)/GaP Alloys—Annealing in steps increases the figure of merit. (Licensing Opportunity)

0592 Ultra-High-Molecular-Weight Silphenylene/Siloxane Elastomers—These elastomers have enhanced thermal and mechanical properties.

*Testing & Instrumentation*

0593 Conductivity Measurements on Insulating Foams

*Other Items of Interest*

0611 STM Images Expose Unexpected Atomic Structures of Ultrathin Films

## Medicine & Biology

0594 Advances in Diagnostic and Treatment Methods in Carcinoids

0596 Collection of Viruses, Molecularly Cloned Viruses, Viral Antisera, Chlamydiae, and Rickettsiae

0597 Laboratory Culture of Octopus for Biomedical Research

0598 New Evidence on Role of Fatty Blood Fraction in Heart Disease

0600 Referral Center for Animal Models of Human Genetic Disease

*Software*

0602 Indoor Air Quality Model Version 1.0

*Testing & Instrumentation*

0604 Real Time Speech Formant Analyzer and Display

*Other Items of Interest*

0568 Development of a High Volume Surface Sampler for Pesticides in Floor Dust

0606 Engineer's Refractive Effects Prediction Systems (EREPS)

0607 First Images of DNA Helix Obtained

## Natural Resources Technology & Engineering

0605 Samara Probe for Remote Imaging—This conceptual device would scan automatically, without costly aiming or stabilizing devices. (Licensing Opportunity)

*Software*

0606 Engineer's Refractive Effects Prediction Systems (EREPS)

*Other Items of Interest*

0515 Floating Raceways Developed for Salmon Culture

## Physical Sciences

0607 First Images of DNA Helix Obtained

0608 New, Accurate Measurement Made for R-134a

0609 Surface Properties of Polymers Predicted by Molecular Modeling

*Testing & Instrumentation*

0611 STM Images Expose Unexpected Atomic Structures of Ultrathin Films

0613 Photovoltaic Hydrogen Sensor—The quantum efficiency of a cell decreased in the presence of hydrogen.

*Other Items of Interest*

0589 Functional Microspheres—Tiny beads develop from an aqueous solution. (Licensing Opportunity)

## Transportation & Components

0615 Evaluation of Railroad Tracks

0616 Assessment of Semiempirical Dynamic Stall Models for Turboprop Stall Calculations—Three semiempirical models are compared.

0617 Piloted Simulations of a VISTOL Aircraft—Flight and control characteristics are evaluated. (Licensing Opportunity)

# Agriculture & Food

0515 Floating Raceways Developed for Salmon Culture

0516 Fruit Flies Can't Take the Hot Air

0517 Innovation in Foods: Safety First

0519 Warmed-Over Flavor in Food Delayed by Proteins (Licensing Opportunity)

Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

http://archive.org/details/technotesjul1989cent

# NOAA Technology Brief

**National Oceanic and Atmospheric Administration**
National Marine Fisheries Service
Northwest and Alaska Fisheries Center

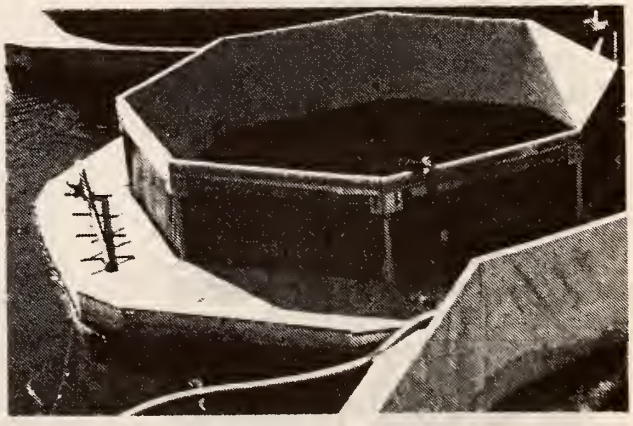
## Floating Raceways Developed for Salmon Culture

NOAA's National Marine Fisheries Service (NMFS) in Alaska has successfully developed and refined a floating salmon culture system that utilizes controlled flow-through rearing water similar to more traditional land-based systems. Notable features of the floating system include low construction and maintenance costs, adaptability to remote sites or locales without suitable areas for shore-based rearing, and high water quality of the rearing environment.

Five different floating raceway designs were tested initially and evaluated before an inverted frustum design was selected as the standard. The floating, vertical raceway operates while suspended in either saline or fresh water and consists of three primary components: (1) an impervious plastic liner, (2) a screened, circular outlet drain, and (3) a flotation collar that provides a walkway and surface support railing. Water enters the raceway through a plumbed surface inlet and exits through the outlet drain. Drain size and in-flowing water volume become critical in maintaining plastic liner turgidity when the raceway is suspended in fresh water.

Several sizes of the floating vertical raceway have been successfully tested at the NMFS remote field station at Little Port Walter in southeastern Alaska. The floating raceway concept is now used in large-scale production of juvenile Pacific salmon in fishery enhancement and restoration projects at several non-Federal facilities. Floating raceways also play a major role in ongoing salmon enhancement research at both Federal and non-Federal facilities.

This work was performed by William R. Heard and Roy M. Martin of the Auke Bay Fisheries Laboratory.



Additional information is available from NOAA ORTA, Suitland Professional Center (SPC), Room 307, Suitland, Maryland 20233. Telephone: (301) 763-4240.

88/NMFS/005

Research Technology
Agricultural Research Service
U.S. Department of Agriculture

# Fruit Flies Can't Take the Hot Air

A new hot air process for zapping fruit flies may give growers in Hawaii and other tropical climates new and profitable opportunities to sell exotic tropical fruits and vegetables to new markets.

The technique--gentle on produce but tough on fruit flies--might be suitable not only for papaya but also for mango, atemoya, carambola, lychee, longan, rambutan, and other tropical specialty crops, says ARS research entomologist John W. Armstrong.

USDA's Animal and Plant Health Inspection Service has accepted the process as a federally approved quarantine treatment for papaya exported from Hawaii and is now awaiting public review of the technique.

Quarantine treatments are an extra precaution to ensure that Hawaiian-grown papaya are free of the three species of fruit flies (Mediterranean, oriental, and melon flies) that could attack it. These pests pose a continuing threat to mainland crops. But mos. commercially grown papaya from Hawaii is so carefully checked that it's highly unlikely a fly-damaged papaya would make it to a mainland supermarket, according to Armstrong.

Female fruit flies ruin papaya by puncturing the fruit to lay eggs just beneath the surface. The wound may also cause staining. The worms that develop from the eggs hasten rot and make the crop worthless.

Hawaiian growers sold $11 million of fresh or processed papaya to Japanese, Canadian, and mainland U.S. markets in 1987.

Here's how the new process is expected to work in packinghouses: hot air, kept at about 50 percent relative humidity (that's midway between moist and dry) is forced over the surface of papayas packed in single layers in ventilated plastic crates. The fruit is gradually heated to 117°F over a 7-hour period, then cooled with water.

Armstrong and colleagues James D. Hansen of ARS and Benjamin K.S. Hu of the inspection service adapted the process from a moist-air, or saturated-vapor, approach. But the new hot air technique is better than that and other methods in killing flies without harming the taste or texture of fruit in the shipment, Amstrong says.

That's because the saturated-vapor heat treatment with hot, moist air and the other approved treatment--a two-stage hot-water bath—kill fruit fly eggs and maggots but occasionally cause scalding or hard, permanent lumps to form in the fruit.

*John W. Armstrong and James D. Hansen are with the USDA-ARS Tropical Fruit and Vegetable Research Laboratory, P.O. Box 4459, Hilo, Hawaii 96720 (808) 959-9138.*

Research Technology
Argicultural Research Service
U.S. Department of Agriculture

# Innovation in Foods: Safety First

Now that the world has come to accept "ham" and other meat delicacies made from poultry rather than pork and beef, another prospect looms on the horizon: Would you believe fish franks?

Actually, the idea is not so farfetched. But how safe would it be? Scientists have already begun pondering the potential safety of adding minced fish or surimi, a paste made from minced fish, to partially replace meat in cured products. The work is being done at the Eastern Regional Research Center operated at Philadelphia, Pennsylvania, by the U.S. Department of Agriculture's Agricultural Research Service.

The research has been requested by USDA's Food Safety Inspection Service (FSIS), which has already received industry queries on permitting the use of minced fish in meat products such as frankfurters, according to Walter Fiddler, a research chemist at the ARS center.

"Industry wants to add the fish for nutritional quality, binding, and gel characteristics," says Fiddler. "The United States has a significant amount of underutilized fish—either whole species or ones where just fillets are used and there are parts left over."

The addition would be an obvious economic boon for the domestic fish industry. The U.S. sausage market, excluding poultry items, totaled about 5.04 billion pounds in 1981, almost twice the size of the U.S. market for fish. With a mere 5 percent minced fish added to meat franks alone, demand for fish flesh would rise some 45 million pounds.

But there are health concerns about adding the fish to frankfurters and their culinary kin, Fiddler notes.

"Nitrite is used in the curing of meats, and it performs a number of important functions," he says. "It gives the cured meat that stable pink color, it imparts the characteristic flavor of cured meat products, and it helps keep the fat from getting rancid. Its most important property is that it prohibits the growth of *Clostridium botulinum*, which causes botulism.

"Although these nitrosamines are found in very low concentrations, parts per billion, some of the ones that have been tested have been found to be animal carcinogens."

Fiddler's study, begun in 1987, is focusing on such factors as harvest time of the fish, the species used, the age of the fish before it's processed, and the length of its stay in frozen storage before processing.

"We want to know how these affect the nitrosamine level of the product after processing and after home cooking," Fiddler says. "There seems to be a lot of industrial interest in the use of surimi; the fish industry is looking for a higher value-added product. This may lead to a new generation of meat products."

### Protein and Iron Source

Another possible meat product additive being studied at the Philadelphia center is the blood that normally goes down the drain at slaughterhouses. As with the extra fish parts, the blood currently offers no income for the meat industry and even poses a problem in waste disposal.

"A number of companies have petitioned FSIS to incorporate some of this blood in cured meat products," says Arthur J. Miller, a food technologist at the laboratory. Consumer studies at Louisiana State University at Baton Rouge have shown meat products with up to 2 percent blood content are acceptable.

"It boosts the nutritional value of the meat product, increasing its protein and iron content."

But once again, *C. botulinum* may complicate matters. "It also needs iron to grow," says Miller. "In cured meat products, the nitrite chemically binds the iron inside *C. botulinum* cells and poisons them; that's how it kills the bacterium. But if you have a lot of iron floating around outside the cell, nitrite will bind with that iron rather than enter the cell, so the bacterium may survive.

"We've made up sausages with nitrite and the blood, and preliminary indications are that high iron will render

the nitrite ineffective against the bacteria. We're looking at using red blood cells, whole blood, or plasma at different percentages."

The outcome of this study, begun last summer and expected to continue through the spring of 1989, "will provide FSIS with information to help them decide whether to permit the blood as an additive in these meat products," Miller says.

### Irradiation To Control Bacteria

The scientists at Philadelphia are not only concerned about what goes into food. They're equally interested in what comes out of it nutritionally. Studies have shown that while high enough levels of irradiation will kill all bacteria and spores of pathogens such as *C. botulinum* in food, the process can affect the vitamin content of certain foods.

"Since 1985, we've set up a program on low-dose irradiation of pork chops and chicken breasts," says Jay B. Fox, Jr., a chemist at the Philadelphia center. "We covered a range of temperatures and doses of irradiation to encompass projected commercial processes for irradiation pasteurization treatments of meats and poultry."

"We went from –20°C to +20°C and from 0 to 7 kiloGrays of irradiation. One kiloGray is equivalent to the absorption of 0.43 BTU of energy per pound. Our interest was in vitamin loss, specifically vitamins such as riboflavin, thiamine, niacin, B12, and B6.

"The B vitamins in pork were especially sensitive to irradiation, particularly thiamine. But in chicken, irradiation caused very low or negligible loss of vitamins."

"Just by itself, thiamine is exceedingly sensitive to irradiation; fractions of a kiloGray will destroy it. But when you put the thiamine in a piece of meat, it takes a hundred times as much irradiation to destroy it. We want to determine why this occurs with thiamine, and also with riboflavin and niacin under irradiation. If we knew more about the conditions which destroy these vitamins, we could control that destruction."

About 32 countries have approved irradiation of more than 40 foods, and the United States was among nations approving a United Nations accord in 1980 that said any food irradiation dose up to 10 kiloGrays would be considered safe.

But use of irradiation as a food preservative in the United States has been minimal. In 1964, the U.S. Food and Drug Administration approved irradiation of potatoes to inhibit sprouting, and spices may be irradiated at doses of 10 to 30 kiloGrays to kill insects and control microorganisms. The FDA in April 1986 adopted approval of irradiation of all fruits and vegetables up to 1 kiloGray, and papayas irradiated with 1 kiloGray to kill insects have been test-marketed. Consumer acceptance of the papayas was reportedly favorable.

In addition, the FDA in July 1985 approved the use of doses of irradiation from 0.3 to 1 kiloGray in pork to control trichina, the worms that cause trichinosis. However, FSIS is still drawing up the procedures by which pork processors can use irradiation.

"We're interested in the compounds that might be produced in meat by irradiation and whether they could be used as markers to determine if the food has been irradiated. Most of the compounds produced by irradiation are the same as those produced by cooking meat—but not all of the products of irradiation have been identified."

Eventually, ARS hopes to provide information on the likelihood of bacterial threats directly to food processors by means of a computer program now being developed at the Philadelphia center.

When the project is completed, processors will be able to type in a simple set of variables—product temperature, pH, salt concentration, nitrite concentration and whether the processing is done with or without oxygen. In response, they'll get a quick answer on the potential growth rate of any of six pathogens in question.

Buchanan says the initial model for one of the pathogens, *Listeria monocytogenes*, could be complete in 3 to 4 months. The other pathogens are *Shigella flexneri, Aeromonas hydrophila, Salmonella typhimurium, Staphylococcus aureas*, and the ever-worrisome *Clostridium botulinum.*

FOR FURTHER INFORMATION: To discuss this effort further, contact Robert L. Buchanan, Walter Fiddler, Jay B. Fox, Jr., and Arthur J. Miller, USDA-ARS Eastern Regional Research Center, 600 Mermaid Lane, Philadelphia, PA (215)233-6620.

**Research Technology**
**Argicultural Research Service**
U.S. Department of Agriculture

*Licensing Opportunity*

# Warmed-Over Flavor in Food Delayed by Proteins

WOF, for warmed-over flavor, occurs when oxygen breaks down fats vital to fresh meaty taste. Sometimes termed "cardboardy" or "painty," WOF can develop when uncured meats are reheated. This includes the precooked, frozen meat in TV dinners, as well as that familiar leftover, the family meatloaf. But in lab studies, scientists found that adding just two-hundredths of an ounce of certain proteins to two pounds of ground beef blocked the warmed-over flavor for up to five days. Scientists made this additive by chemically treating chitin, a substance common in shells of lobsters, crabs and other shellfish. These chitin substances bond to iron, preventing it from speeding up fat breakdown. Scientists say there is commercial interest in their process which may work in other meats, poultry and fish.

FOR ADDITIONAL INFORMATION: To discuss this effort further, contact Food Flavor Quality Research, Southern Regional Research Center, New Orleans, LA, John R. Vercellotti; (504) 286-4421.

# Computers

0520 The Strategic Defense Initiative Technology Applications Information System

0521 Navy Experimenting with Computerized Executive Networking Survey System (CENSUS)

0522 OPSMOP: Parallel Symbol-Matching Coprocessor for Rule-Processing Systems

*Software*

0524 Eliminating Tracking System Clock Errors—Problems of redundancy and correlation are avoided.

0525 Stellar Inertial Navigation Workstation—Software and hardware are assembled to support specific engineering activities.

*Other Items of Interest*

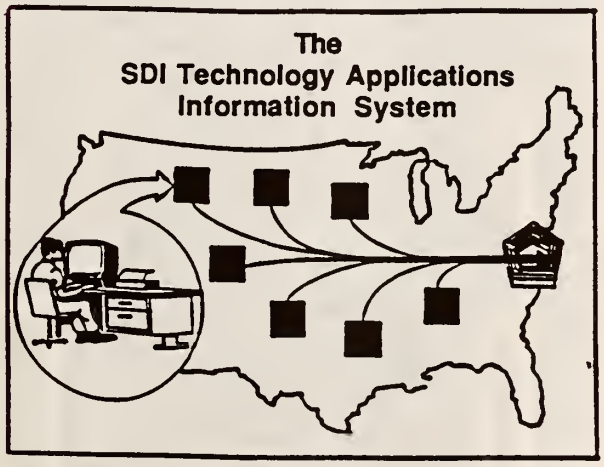
0528 Acoustic Regenerator (Licensing Opportunity)

0530 Ultimate Low-Loss Electro-Optical Cable (Licensing Opportunity)

# Department of Defense Fact Sheet

## The Strategic Defense Initiative Technology Applications Information System

The Department of Defense's Strategic Defense Initiative Organization (SDIO) has developed a technology applications information system (TAIS) data base which, once accessed, provides its user with more than 1000 unclassified, nonproprietary abstracts that identify emerging technologies developed through research on the Strategic Defense Initiative (SDI) that can also serve as a source of innovation for commercial ventures and other research and development efforts. This information is provided to help you identify investment opportunities or supplement research and development activities you might undertake to move an emerging technology from the laboratory to the marketplace.




SDI provides such an opportunity for technology transfer since it is redefining what is considered state of the art through the research and development it has initiated in a vast array of new and unexplored areas. Because this approach is so broad in its scope, the products and processes generated from SDI research can also serve as a source of innovation for commercial ventures and research and development efforts which benefit the nation's economy, defense, and research and development base.

SDI research has already, for instance, produced spinoffs of value to the medical community, industry, engineering, the defense establishment, and computer science. It has also served as a foundation for the research and development of products and processes for the transmission and conservation of energy, space transportation, agriculture, and the protection and cleanup of the environment.

Information about SDI spinoffs in these different areas can be obtained through the TAIS. The TAIS, once accessed, provides its user with unclassified, nonproprietary abstracts covering SDI research in a broad array of areas including superconductivity, sensors, lasers, computer technology, electronics, energy, and materials and industrial processes. The TAIS, updated with new information files monthly, also provides information on specific federally set-aside research opportunities for small businesses; points of contact at federal, state, and local technology transfer offices and private sector foundations; and accessibility to other technology information data bases. Once the user has identified those technologies from the TAIS for which he or she wants more information, SDIO works as an intermediary to put that person in contact with the SDI researcher or developer of the technology.

Any US citizen can access the TAIS by computer modem once he or she has completed a DD Form 2345, "Militarily Critical Technology Data Agreement," certifying that he or she will not release information gained from the TAIS to foreign nationals without prior approval, authorization, or license under U.S. export control law. Once the user's eligibility has been certified by the Defense Logistics Agency, that person can then be hooked up with the TAIS at no charge other than the cost of the phone call.

FOR ADDITIONAL INFORMATION: Contact the Systems Administrator, the SDIO Office of Technology Applications, Room 1E1023, The Pentagon, Washington, DC 20310-7100 for information on the TAIS or how to get a DD Form 2345; (202) 693-1563.

# NAVY
## Domestic Technology Transfer Fact Sheet

# Navy Experimenting with Computerized Executive Networking Survey System (CENSUS)

As sophisticated technology continues to impact organizations, a growing need for efficient, flexible, and cost-effective training programs becomes paramount. To cope with these increased training demands, a team of researchers at Navy Personnel Research and Development Center (NPRDC), San Diego, California, formulated a microcomputer-based multi-user system that can enhance training quality and assess training effectiveness. Computerized Executive Network Survey System (CENSUS) allows training-related surveys to be conducted efficiently, accurately, and reliably.

CENSUS was developed primarily to survey the attitudes of Navy civilian workers. Attitude assessment can help managers establishing deficiencies in current training, uncover areas where training is perceived as lacking, and obtain feedback about the acceptance of a new training delivery system. Drawbacks to attitude measurement can be reduced through CENSUS. Through a feature called branching, CENSUS can customize surveys based on the user's personal characteristics, or through responses to previous questions.

Researchers at NPRDC are currently developing system software that will run on CENSUS. The system will consist of an interactive software program that provides a manager who is untrained in questionnaire design with a prompting, retrieval and feedback system to produce reliable and useful surveys, specify random and representative samples, and provide necessary data analyses. It would be possible for managers to develop questionnaires independently from experts and interactively with the computer. The components will be a menu-driven control system that includes an editor and format specifier, and a database that includes survey data from previous questionnaire administrations and standardized questionnaires in general. Hence, the quality of training-related surveys will be improved, and their applicability to areas such as program evaluation and organizational communication made easier.

The CENSUS system can be used by managers to conduct organizational surveys as part of an overall organizational feedback system. By automating results of the surveys, policy-makers, managers, and employees alike will be able to have meaningful and timely feedback.

*For Additional Information:*

Backup material on this effort is available from:

Navy Domestic Technology Fact Sheet Reader Reply Service
Code E211
Naval Surface Weapons Center
Dahlgren, VA 22448-5000
(703) 663-8921

Refer to 131204/TN

*Oak Ridge National Laboratories*

# OPSMOP: Parallel Symbol-Matching Coprocessor for Rule-Processing Systems

OPSMOP (OPS matching-only processor) is an application-specific integrated circuit that implements an advanced artificial intelligence architecture (Fig. 1). It performs, in parallel, the "matching" task associated with rule-based expert systems, speeding up the execution of expert systems by a factor of 5 to 20 over conventional sequentially executed expert systems.

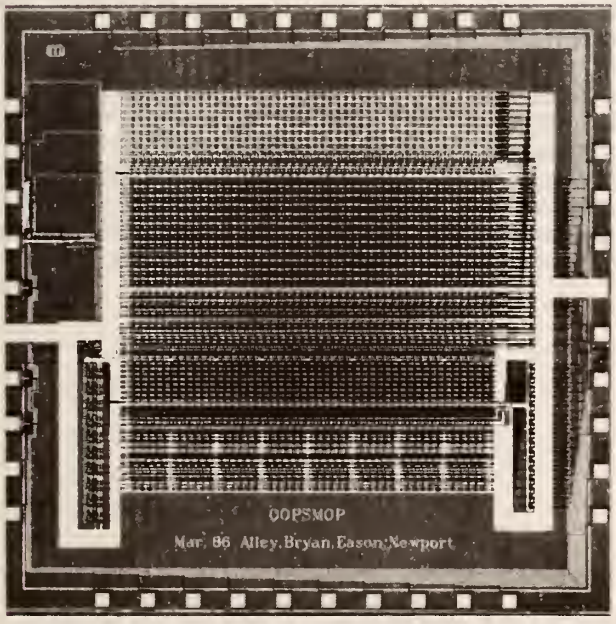



**Fig. 1. The OPSMOP integrated circuit. Photograph courtesy of Melgar Photographers, Inc., Santa Clara, California.**

In an OPS expert system application in which the language employs a set of rules, a global data base, and an inference engine that performs an iterative recognize-act cycle of match, conflict resolution, and rule firing, the matching task accounts for 85 to 95% of the total computational time. OPSMOP is a hardware accelerator for pattern-matching processes such as those found in rule-based expert systems, particularly in the OPS language. It is also applicable to other matching tasks, such as queries found in relational data-base systems.

In a typical target expert system application for synthesis of chemical compounds, matching requires about 18 ms out of 20 ms per rule-processing cycle. Running at a modest 1-MHz clock frequency, OPSMOP performs the same matching task in 9 clock cycles (0.009 ms) per rule-processing cycle. This essentially eliminates the matching task as the bottleneck in the rule-processing cycle. By using this chip in a hardware architecture for expert systems, the overall system performance could be improved by a factor of from 5 to 20 over that of current sequential software (2.009 ms vs 20 ms).

As the pattern-matching requirements are extended in width, this chip may be cascaded to meet the required width without increasing either the matching time or the software development time. Most parallel computing approaches are expensive in terms of hardware and software. These costs rise very rapidly as the number of parallel paths increases. OPSMOP is inexpensive and will become even more so with volume production because it is implemented in very-large-scale integrated circuit technology.

OPSMOP can be targeted for general use outside the expert system field. For example, it can be applied in relational data-base implementations and file verification for mass storage devices such as optical disks. Minor architectural changes in the input-output structure of the present OPSMOP would allow it to be optimized for this type of application.

***Additional information:***

Office of Technology Applications
Martin Marietta Energy Systems, Inc.
P.O. Box 2008
Oak Ridge, TN 37831-6257

Telephone: (615) 574-4192; FTS 624-4192

D. F. Newport et al., "A Parallel Symbol-Matching Co-Processor for Rule Processing Systems," pp. 57-81 in *Proceedings of the 1986 International Conference on Systems, Man and Cybernetics, Atlanta, October 14-17, 1986.* Institute of Electrical and Electronics Engineers, Inc., New York, 1986.

## Eliminating Tracking-System Clock Errors

Problems of redundancy and correlation are avoided.

The ORTHO computer program eliminates the effect of clock errors in the differential solutions for the positions of users of the Global Positioning System (GPS). The GPS is being developed by the U.S. Air Force and will use up to 24 NAVSTAR satellites to broadcast navigation messages for worldwide coverage. The normal positioning technique involves the use of one receiver, which receives signals from at least four GPS satellites. For higher accuracy, it is often necessary to use a differential technique that requires more than one receiver. A geodetic measurement in which all receivers are on the ground enables the determination of the relative locations of the ground sites.

The main application of the ORTHO program is in the elimination of clock errors in a tracking system based on the GPS. The measured distance (pseudorange) from a GPS receiver contains errors due to differences between the receiver and satellite clocks. The conventional way of eliminating clock errors is to take the differences between the pseudoranges between different GPS satellites and receivers. The Householder transformation used in this program performs a function similar to the conventional single differencing or double differencing. This method avoids the problem of redundancy and correlation encountered in a differencing scheme. It keeps all information contained in the measurements within the scope of a least-squares estimation. For multiple-transmitter-and-receiver GPS tracking networks, this method is, in general, more accurate than the differencing technique.

This program is based in part on the assumption that the non-clock-measurement partial derivatives for the particular application were computed earlier by another program. With the partial derivatives and information to identify the transmitters and receivers as the input, the program performs the Householder transformation on the partial derivatives. The transformed partial derivatives are the output of the program and can be used as input to the filter program in the subsequent estimation process. Clock partial derivatives are generated internally and are not part of the input to the program.

ORTHO is written completely in FORTRAN 77 on the DEC VAX operating under VMS 4.5 and requires 805K of central memory. LINPACK, a public-domain subroutine package distributed by Argonne National Laboratory and IMSL subroutine library, is required. The program was released in 1988.

*This program was written by Jiun-tsong Wu and William I. Bertiger of Caltech for* **NASA's Jet Propulsion Laboratory**.

*NPO-17098/TN*

**FOR ADDITIONAL INFORMATION**

*CONTACT:*

**COSMIC®**
112 Barrow Hall
University of Georgia
Athens, GA 30620
(404) 542-3265

## Stellar Inertial Navigation Workstation

Software and hardware are assembled to support specific engineering activities.

The Stellar Inertial Navigation Workstation (SINW) is an integrated computer workstation that provides systems and engineering support functions for Space-Shuttle guidance and navigation-system logistics, repair, and procurement activities. The workstation consists of personal-computer hardware, packaged software, and custom software integrated together into a user-friendly, menu-driven system.

The use of low-cost personal-computer equipment makes it economically feasible to dedicate the SINW to a limited set of applications. The system includes data-base and reporting functions for the scheduling of project activities, manpower, the preparation of correspondence, engineering design changes, items that require action by management, requirements table baseline, and the preparation of charts. With modification, the SINW could be used in other similar engineering activities in industry. The methodology and principles of the workstation implementation strategy can be applied in business and industry to develop similar workstations.

The software configuration of the SINW includes the following packages:

- IBM PC DOS (including the IBM LINK program);
- Microrim's R:base 4000 Database Management System, Extended Report Writer (XRW), and Program Interface (PI) Library;
- FPA's File Path Program;
- Seaware Corporation's Extended Batch Language (EBL) BAT program;
- IBM's Fixed Disk Organizer (FDO) program;
- Micropro's WordStar, CorrectStar, and Mail Merge;
- Lotus 1-2-3; and
- Hayes Smartcom Software.

The higher-level languages used for custom software programming include IBM's BASIC language and Microsoft Pascal.

The SINW program was developed in 1984. It is designed to operate on an IBM PC XT configured with one 360-kb floppy drive, one 10-Mb fixed disk, a monochrome CRT with Hercules HiResolution Board, an HP LaserJet printer, a Hayes Smartmodem, and an HP 7475A Plotter.

*This program was written by W. Johnson, B. Johnson, and N. Swaminathan of Abacus Programming Corp. for* **Johnson Space Center**. *For further information, Circle 160 on the TSP Request Card.*
*MSC-21093*

**FOR ADDITIONAL INFORMATION**

*CONTACT:*
**COSMIC®**
112 Barrow Hall
University of Georgia
Athens, GA 30602
(404) 542-3265

# Electrotechnology

0526 New Calibration Services Offered

0527 Narrow Spectral Bandwidth, UV Solar Blind Detector (Licensing Opportunity)

0528 Acoustic Regenerator (Licensing Opportunity)

0530 Ultimate Low-Loss Electro-Optical Cable (Licensing Opportunity)

0532 BIN Diode for Submillimeter Wavelengths—Uses would include mixers and harmonic generators in receivers for atmospheric and space spectroscopy. (Licensing Opportunity)

0534 Compression of Data in Imaging Radar Polarimetry—The number of data is reduced by a factor of 12.8.

0536 Hybrid Infrared Imager—An experimental device has low noise and high uniformity.

0537 Improved Method for Making Infrared Imagers—Properties of a thin dielectric layer are adjusted precisely.

0538 Microwave Comb Generator—Stable reference tones aid the testing and calibration of microwave receivers.

0540 Automatic Frequency Control for DMSK Receiver—Performance is analyzed theoretically and experimentally. (Licensing Opportunity)

0541 Power-Supply-Conditioning Circuit—Fluctuations of voltage are suppressed in power supplies for precise radio-frequency circuits. (Licensing Opportunity)

0542 Optimal Placement of Multiple Antennas—Obscuration by the structure or vehicle is taken into account.

*Testing & Instrumentation*

0544 Capacitive Displacement Sensor with Frequency Readout—The frequency varies approximately linearly with displacement.

0545 Low-Power Magnetic Current Sensor—Direct current is sensed via a saturable-core reactor.

*Other Items of Interest*

0548 Stable, Efficient Thin Film Solar Cell Developed

*Federal Laboratory Resource*

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## New Calibration Services Offered

The explosive growth of optical fiber use in the communications industry has resulted in a demand for calibration services. NIST's Boulder, Colo., laboratory now offers measurements of optical laser power and energy at wavelengths and power levels of interest to fiber optic producers and users. Measurements are based on a standard reference instrument called the C-series calorimeter. An electrically calibrated pyroelectric radiometer (ECPR) is calibrated against the calorimeter and is then used to calibrate optical power meters at wavelengths of 850, 1300, and 1550 nanometers. To improve calibration capabilities, NIST is preparing test measurement systems for detector linearity, detector uniformity, and detector spectral responsivity. These systems should be available in 6 months.

FOR ADDITIONAL INFORMATION: For a paper outlining NIST's optical power measurement capabilities, contact Fred McGehan, Div. 360, NIST, 325 Broadway, Boulder, Colo. 80303. For more information on calibration services, contact Thomas R. Scott, Div. 724 same address, or phone (303)497-3651.

# U.S. Navy Technology Application

## Narrow Spectral Bandwidth, UV Solar Blind Detector

A Detector/Receiver was constructed for use in an optical communication system. The present invention is directed to providing an apparatus and method for improving the detection of 253.7 nm radiation coming, for example, from a mercury discharge source. A wide aperture, wide field of view surface is provided with a coating that blocks some of the radiation outside of the 253.7 nm impinging radiation. A ruby material absorbs the radiation and provides fluorescent emissions. A glass layer passes the fluorescent emissions and a photomultiplier tube sensitive to radiation in the fluorescent spectrum gives output signals representative of the impinging radiation. Shifting the 253.7 nm radiation into the fluorescent spectrum allows the use of less expensive photomultiplier tubes.

A prime object of the invention is to provide for an improved detection capability for 253.7 nm radiation.

Another object of the invention is to provide for a wide aperture wide field of view enhanced detector for an omni-directional, nonline-of-sight communication system.

STAGE OF DEVELOPMENT

It would be easy to apply and construct the hardware for application in communications and various optical devices.

PATENT STATUS

United States Patent Number 4,731,338; 15 March 1988

ADDITIONAL INFORMATION

Work was performed in Code 843, Electro-Optic Devices Branch, Naval Ocean Systems Center, San Diego, CA 92152-5000

# U.S. Navy Technology Application

## Acoustic Regenerator

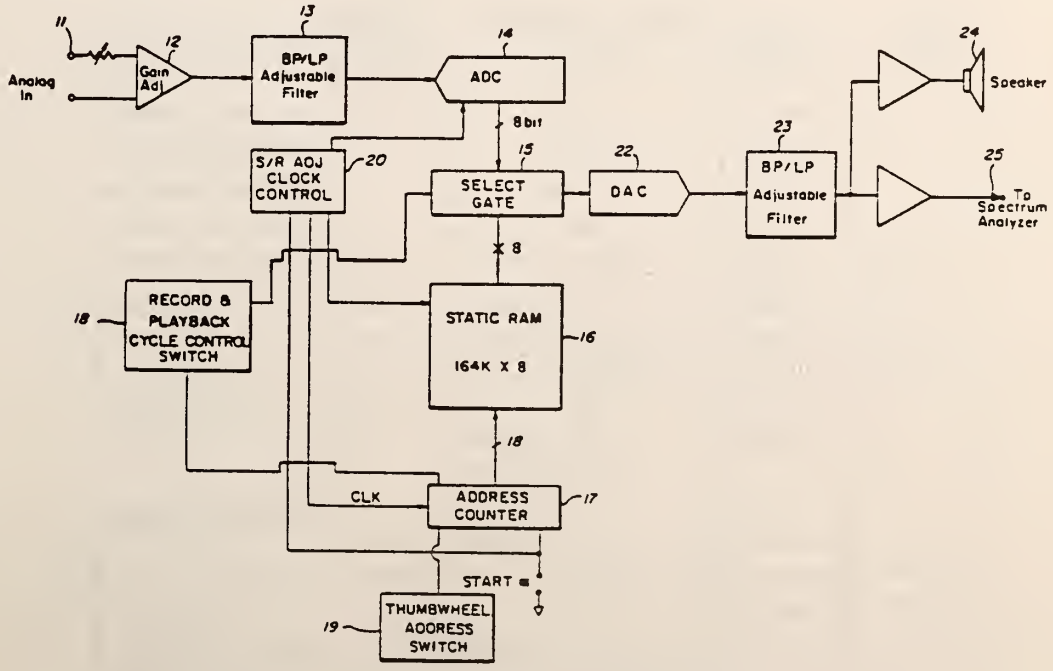
The regenerator was designed primarily for storing audio data such as speech, signatures or any acoustic information. The data once stored in solid state memory is then available for looping, e.g., playing back indefinitely or n times, where n=1 to inf. The basic design covers d.c. to 20khz, however the clock may be modified for data beyond the audio range. The sample rate is adjustable for frequency translation either up or down. The prototype has memory (RAM) for eight minutes maximum at the lowest sampling rate. The length of storage is a direct function of memory size.

STAGE OF DEVELOPMENT

A prototype was constructed in 1986 and used for dissection of data taken off tape. By choosing a portion of info from the tape and storing it in RAM and looping, jockying the tape back and forth to look at the data was no longer necessary. The start/stop times were always exact with no overlap. This gave us a tremendous advantage in accuracy and time saving.

APPLICATIONS

This device has applications in speech, music, sonar and data even beyond the human sound range. Speech synthesis and speech recognition analysis. Audio crypto systems and even music development. Once the info is stored in RAM (memory), every sample of data can be accessed (addressed) and controlled. For example, data can be stored and then played back in any order; reversed, segmented and translated.



PATENT STATUS

United States Patent Number: 4,759,067

PUBLICATIONS:

This was developed for another project. There is no separate publication except in the patent disclosure.

ADDITIONAL INFORMATION:

R. E. Page, Code 552, Naval Ocean Systems Center, San Diego, CA 92152-5000.
Telephone (619) 553-5380.

# U.S. Navy Technology Application

## Ultimate Low-Loss Electro-Optical Cable

A cable design has been developed which is capable of transmitting power and data for deep ocean systems. This design combines optical fiber, a rolled metal tube conductor and armor, and kevlar strength member in a coaxial geometry. The resulting cable has sufficient power and data transmission capability and strength to be deployed in the deep ocean.

STAGE OF DEVELOPMENT

The design has been experimentally verified.

APPLICATIONS

This cable has application in the areas of commercial and military telecommunications, military surveillance, and oceanography.

| CABLE COMPONENT | SPECIFIC GRAVITY | CROSS SECTION $A_i$ ($CM^2$) | WEIGHT (KGF/KM) | S (1%) (KGF) |
|---|---|---|---|---|
| OPTICAL FIBER (1) | 2.20 | 0.00012 | 0.027 | -------- |
| SILICONE BUFFER (1) | 1.20 | 0.00073 | 0.088 | -------- |
| *POLYESTER BUFFER(1) | 1.25 | 0.00111 | 0.139 | -------- |
| VOID-FILLING GEL | 1.14 | 0.0168 | 1.917 | -------- |
| COPPER CONDUCTOR | 8.89 | $(\pi/4)(D_3^2-0.0225)$ | $890A_C$ | $4500A_C$ |
| DIELECTRIC | 0.92 | $(\pi/4)(D_4^2-D_3^2)$ | $92A_d$ | -------- |
| KEVLAR-49 | 1.45 | $0.565(\pi/4)(D_5^2-D_4^2)$ | $145A_K$ | $11,250A_K$ |
| EPOXY MATRIX | 1.19 | $0.435(\pi/4)(D_5^2-D_4^2)$ | $119A_e$ | -------- |
| POLYURETHANE JACKET | 1.14 | $(\pi/4)(D_6^2-D_5^2)$ $=0.2\pi(D_5+0.2)$ | $114A_p$ | -------- |
| SEAWATER BUOYANCY GAIN | $1.032_5$ | $(\pi/4)(D_5+0.4)^2$ | -103.5A | -------- |
| TOTALS | | | $W_W$ | S(1%) |

* OPTIONAL BUFFER, AND NOT CONSIDERED IN THIS DESIGN.

PATENT STATUS

United States Patent Number: 4,763,981, 16 Aug 1988

PUBLICATIONS

Details of the analysis are contained in the patent disclosure. Further information contained in:

Wilkins, G.A., "A Miniaturized, Transoceanic, Fiber Optic Communications Cable," Proceedings of FOC '81, San Francisco, CA, 1-3 Sep 1981, pp 78-83

Wilkins, G.A., "How Small Can an Electro-Optical Transoceanic Cable Be?" Proceedings of the International Telemetering Conference, San Diego, CA, 13-15 Oct 1981

Additional Information

A.T. Nakagawa, Code 534, Naval Ocean Systems Center, P.O. Box 997, Kailua, HI 96734-0997. Telephone: (808) 257-1609

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# BIN Diode for Submillimeter Wavelengths

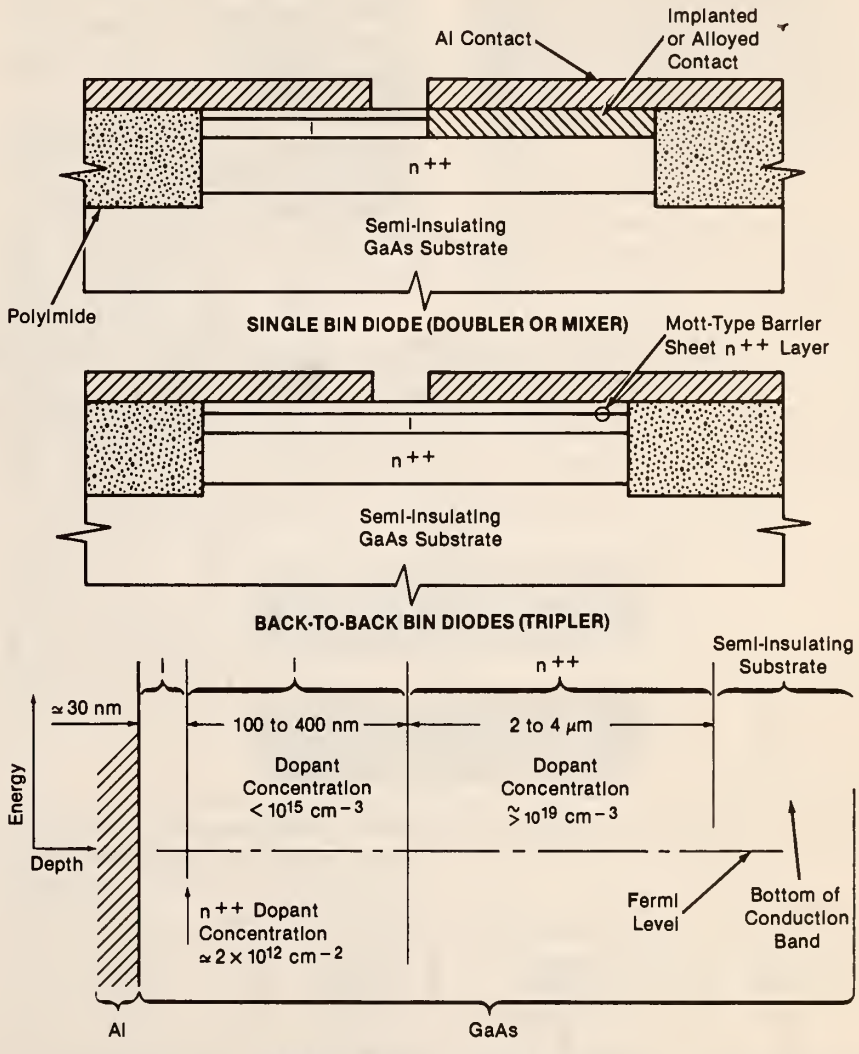
Uses would include mixers and harmonic generators in receivers for atmospheric and space spectroscopy.

A proposed diode structure comprising barrier/intrinsic/$n^+$ (BIN) semiconductor layers should be useful for the generation of harmonics or for heterodyne mixing in receivers for atmospheric and space spectroscopy operating at millimeter and submillimeter wavelengths. Used as frequency doublers or triplers, diodes of the new type would extend the frequency range of present solid-state oscillators (e.g., GaAs Gunn diodes). Although highly efficient and tunable, such oscillators are currently limited to frequencies below about 100 GHz.

The proposed diode (see figure) would be formed by selective doping during epitaxial growth, starting with a semi-insulating substrate. The use of high-mobility semiconductors like GaAs would extend the cutoff frequency. Either molecular-beam epitaxy (MBE) or organometallic chemical-vapor deposition can be used to form the layers of the diode. A planar growth process (e.g., MBE) would permit subsequent fabrication of arrays of diodes by standard photolithographic techniques, to achieve quasi-optical coupling of submillimeter radiation.

The new diode structure would overcome difficulties encountered in the fabrication of a recent thin metal-oxide/silicon (T-MOS) design. Both the BIN and the T-MOS devices would be much more efficient than the GaAs Schottky diodes currently used to generate harmonics. Unlike the T-MOS structure, the BIN diode would require no insulator layer but instead would rely on a Mott-type barrier formed in the semiconductor by selective doping. In addition, the intrinsic layer of the BIN diode would provide an active space-charge-limited region that would result in enhanced nonlinearities in the dependence of the capacitance upon voltage (especially at reduced operating temperatures) and minimize the resistance•capacitance time constant to maximize the cutoff frequency.

The back contact of the BIN diode would be a heavily negatively doped ($n^{++}$) layer, 2 to 4 μm thick. A 100- to 400-nm-thick intrinsic or undoped intrinsic (i) layer would provide the space-charge-limited region. An $n^{++}$ sheet of dopant with a density•thickness product of about $2 \times 10^{12}$




**The BIN Diode** can be produced in various configurations: a single diode for use as a frequency doubler or mixer or a pair of diodes back-to-back for a frequency tripler. Also shown are the energy and doping profiles of the diode.

atoms/cm$^2$ would terminate the Mott-type barrier formed between the intrinsic layer and the aluminum front contact. This sheet should be as thin as possible (<2 nm) for optimum performance.

*This work was done by J. Maserjian of Caltech for* **NASA's Jet Propulsion Laboratory**.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL*
*Refer to NPO-17258/TN*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

# Compression of Data in Imaging Radar Polarimetry

The number of data is reduced by a factor of 12.8.

Algorithms have been developed to reduce the number of radar polarimetric data that must be processed to synthesize an image of an arbitrary combination of transmitting and receiving polarizations. Such techniques for the compression of data are needed because a typical synthetic-aperture-radar polarimetric image contains 4,194,304 one-look picture elements (4,096 in azimuth by 1,024 in range) and requires about 128 megabytes of storage capacity. The algorithms bring the image-processing requirements within the computing capabilities of typical users, without degrading the images excessively.

One of the algorithms is based on the scattering matrix, which is a 2-by-2 matrix of complex numbers that specify the amplitude and phase relationships among the horizontally- and vertically-polarized transmitted (or incident) and received (or backscattered) radar signals. The other algorithm is based on the phase matrix, a 4-by-4 matrix of real numbers that specifies the relationship between the transmitted and received Stokes vectors. The Stokes vector **G** is a four-dimensional vector defined by

$$G_0 = a_h^2 + a_v^2,\ G_1 = a_h^2 - a_v^2,\ G_2 = 2a_h a_v \cos(\delta),\ G_3 = 2a_h a_v \sin(\delta)$$

where $a_h$ and $a_v$ are the horizontal and vertical amplitudes, respectively, and $\delta$ is the phase difference between them. Either matrix can be used to construct an image of any combination of polarizations, and both matrices are equivalent as long as the waves are fully polarized ($G_0^2 = G_1^2 + G_2^2 + G_3^2$). However, the Stokes-vector and phase-matrix representation allows for a diffuse (depolarized) component, the importance of which can be measured by $G_0^2 - G_1^2 - G_2^2 - G_3^2$.

In the scattering-matrix approach to the compression of data (see Figure 1), four consecutive picture elements along the azimuth direction are combined into one by constructing an "average" scattering matrix $S_{ij}$ from the scattering matrices $A_{ij}$, $B_{ij}$, $C_{ij}$, and $D_{ij}$ of the four elements. The amplitude of an element of the "average" matrix is given by

$$|S_{ij}| = [A_{ij}A_{ij}^* + B_{ij}B_{ij}^* + C_{ij}C_{ij}^* + D_{ij}D_{ij}^*]^{1/2}$$

while the phase of the element is given by

$$Arg(S_{ij}) = Arg[A_{ij}A_{hh}^* + B_{ij}B_{hh}^* + C_{ij}C_{hh}^* + D_{ij}D_{hh}^*]$$

where the subscript $h$ denotes horizontal polarization, either of the subscripts $i$ and $j$ can denote horizontal or vertical polarization, and the phase of $S_{hh}$ is arbitrarily set at zero. The calculation of the phase in this method puts more weight on vectors of large amplitude, which are presumably less vulnerable to noise.

The information to be coded for the "average" picture element consists of four amplitudes and can be stored in 8 bytes: 2 bytes for the maximum amplitude expressed as a mantissa and an exponent, 3 bytes for the remaining amplitudes, and 3 bytes for the phases. Thus, the data have been reduced to 1,024-by-1,024 picture elements of 8 bytes apiece, representing an overall reduction by a factor of 16.

In the phase-matrix approach (see Figure 2), four consecutive picture elements in the azimuth direction are combined into one by simple addition of their phase matrices: this is equivalent to four-look averag-

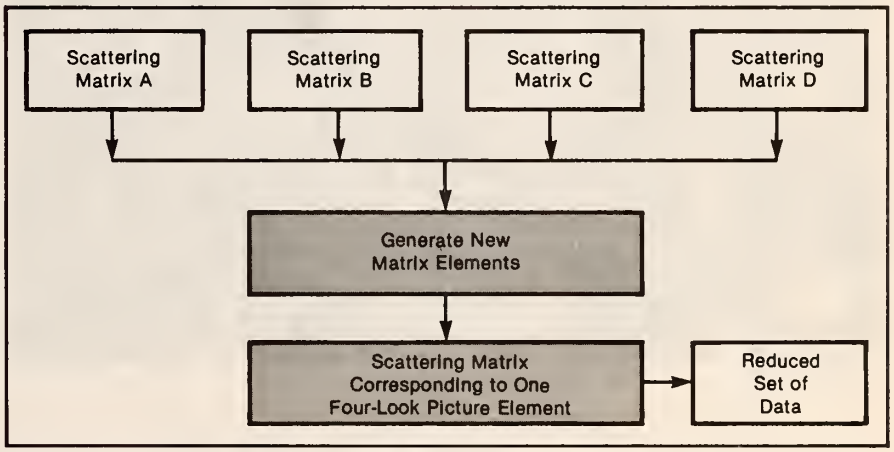

Scattering Matrix A
Scattering Matrix B
Scattering Matrix C
Scattering Matrix D
Generate New Matrix Elements
Scattering Matrix Corresponding to One Four-Look Picture Element
Reduced Set of Data

Figure 1. In the **Scattering-Matrix Approach** to the reduction of image data, four adjacent picture elements are combined into one by synthesizing a new scattering matrix from the scattering matrices of the four elements.

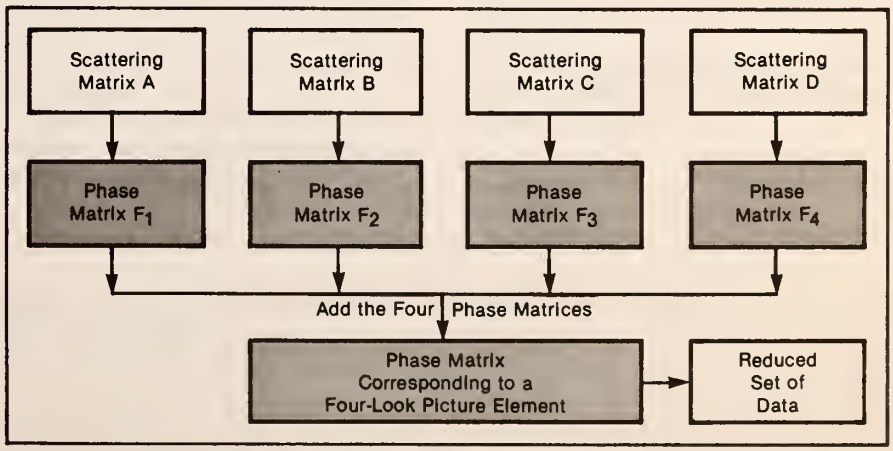



Figure 2. In the **Phase-Matrix Approach**, phase matrices are generated from the scattering matrices of four adjacent picture elements, and the four phase matrices are added to combine the four picture elements into one.

ing. In this case, the complete phase matrix of an "average" picture element can be stored in 10 bytes, and the resulting image of 1,024-by-1,024 elements can be stored in 10-by-1,024-by-1,024 bytes, representing an overall reduction by a factor of 12.8.

The performances of the two approaches were measured in terms of the errors between original polarization data from representative terrain and the polarization signatures synthesized from the reduced sets of data. The scattering-matrix approach was found to yield errors approaching $10^{-2}$, while the phase-matrix approach typically yielded errors less than $10^{-3}$.

*This work was done by H. A. Zebker, D. N. Held, J. J. Van Zyl, P. DuBois, and L. Norikane of Caltech for* **NASA's Jet Propulsion Laboratory**.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL*
*Refer to NPO-17184/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

# Hybrid Infrared Imager

An experimental device has low noise and high uniformity.

An infrared imaging device combines an array of InSb photodetectors with an array of silicon field-effect-transistor (FET) switches. The InSb chip forms a roof over the Si chip, each InSb detector cell engaging an indium bump on the corresponding Si switch cell below it. As the FET switches in the 128-by-128 array turn on in sequence, they read out the charges on the 128-by-128 array of photodetectors and multiplex them in a serial output that represents the pattern of light on the array of photodetectors.

When fully developed, the double-chip device will be useful in sensitive infrared cameras for astronomy, medicine, inspection, and military surveillance. It can read out image data at rates up to 10 MHz and can readily be expanded to a 256-by-256 array.

The multiplexer chip is 0.4 in. (1 cm) square. The detector chip is 0.3 in. (0.76 cm) square. The pixels measure 50 $\mu$m square, and their centers are spaced 60 $\mu$m apart. The assembled chips are housed in a 3/4- by 3/4- by 1/8-in. (1.9- by 1.9- by 3.2-mm) package.

The multiplexer chip is first bonded to a ceramic carrier for processing. The carrier also serves as a base for the package. Indium bumps are plated on the switch cells photolithographically. A similar set of indium bumps is plated on the photodetector cells (see figure), from the same photolithographic mask, to ensure precise registration with the bumps on the multiplexer.

The detector chip is placed on the multiplexer chip, bump to bump. Pressure and heat are applied so that the bumps bond together. The outer surface of the InSb chip (which is the substrate of the array of photodiodes) is polished to reduce its thickness to 10 $\mu$m, enabling it to transmit light more efficiently to the photodiode junctions. Plans call for further reductions of the thickness to only 5 $\mu$m.

**Indium Bumps** on an array of InSb photodetectors mate with similar bumps on the multiplexer. The rough texture of the bumps increases the contact area.

When tested at a temperature of 80 K, the assembled device exhibited a noise of only 950 electron charges. The uniformity of responsivity differed among pixels by only 8 percent. The nonuniformity of dark current was even smaller — only about 5 percent.

*This work was done by Gary C. Bailey of Caltech for* **NASA's Jet Propulsion Laboratory.** *NPO-17218 /TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Goddard Space Flight Center, Greenbelt, Maryland*

# Improved Method for Making Infrared Imagers

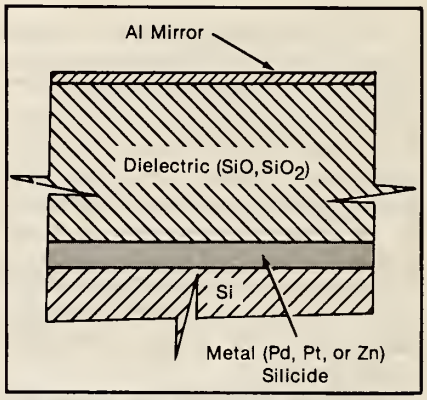
Properties of a thin dielectric layer are adjusted precisely.

A deposition technique has been found to improve the fabrication of infrared imaging devices. The technique is applied to a dielectric layer of SiO and $SiO_2$ (see figure), which is critical to the operation of a device. For an imager to work properly, thickness of the dielectric layer has to be adjusted precisely in coordination with its absorption coefficient and the wavelength of the light to be imaged.

The absorption coefficient and index of refraction are adjusted by altering the composition, $SiO_x$. The dielectrics used previously — electron-beam-evaporated $SiO_x$ or chemical-vapor-deposited $SiO_2$ — produce satisfactory layers but have several disadvantages. The stoichiometry of the $SiO_x$ (and, therefore, the index of refraction and the absorption coefficient) are variable and difficult to control in the electron-beam process. Chemical-vapor deposition produces a dielectric layer of controllable index of refraction, but the high temperature of this process degrades the underlying metal silicide layer during the 30 minutes needed to deposit the dielectric layer. Furthermore, chemical-vapor deposition necessitates the use of a cumbersome lift-off technique during subsequent processing.

In the new technique, a suitable $SiO_2$ dielectric is deposited at room temperature by a magnetically-enhanced glow discharge, using silane and nitrous oxide as precursors. This technique enables the control of the thickness and the index of refraction of the dielectric to within ±1 percent; in comparison, the previous techniques yielded ±10-percent variations.

The $SiO_2$ deposited by the new technique can be wet-etched, and therefore the lift-off step can be eliminated. The net result is higher yield and lower cost, without sacrifice of the performance of the imagers.




The **New Deposition Process** enables the adjustment of the thickness and index of refraction of the critical dielectric layer to within ±1 percent.

*This work was done by G. Kaganowicz, A. G. Moldovan, and J. W. Robinson of David Sarnoff Research Center, for* **Goddard Space Flight Center**. *No further documentation is available.*
*GSC-13135/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

# Microwave Comb Generator

Stable reference tones aid the testing and calibration of microwave receivers.

A signal generator puts out stable tones in the frequency range of 2 to 10 GHz at all multiples of a reference input frequency, which can be any frequency up to 1 MHz. Called a "comb generator" because its spectral plot resembles a comb, the circuit is used in testing microwave and spread-spectrum wide-band receivers. The design and physical configuration of the circuit result in a broad, relatively flat comb spectrum and high output.

The comb spectrum consists of the harmonics of the repetition frequency of the input pulses. The comb spectrum is generated in a step-recovery diode driven by a two-stage, high-speed amplifier (see Figure 1). The second stage of the amplifier acts as a switch that connects and disconnects a reverse-current source to or from the step-recovery diode. A smaller forward-current source is always connected to this diode, and when the reverse-current source is connected, it reverse-biases the diode to cause the step voltage recovery that generates the pulses. A Schottky diode on the output of the second amplifier stage keeps the output transistor from saturating when the step-recovery diode is turned off.

The forward and reverse current sources are provided by a dc bias circuit. The amplitudes of the forward and reverse currents and, therefore, of the comb-generator output are proportional to the value of a digital control word that is fed into a digital-to-analog converter. The dc bias maintains a constant ratio between the forward and reverse currents when the control word changes the amplitude, but the ratio is varied by a thermistor to compensate for the effects of the variation of temperature on the step-recovery diode.

In the microwave portion of the circuit, the output is taken across the inductor element to eliminate the need for the dc blocking capacitor typically used in a step-recovery-diode circuit. The microwave circuit is connected to the driving circuit through a low-pass filter that consists of two chip capacitors at opposite ends of a parallel-conductor, air-insulated transmission line. A loop of gold foil acts as the inductor (see Figure 2). A sandwich consisting of the step-recovery diode and one of

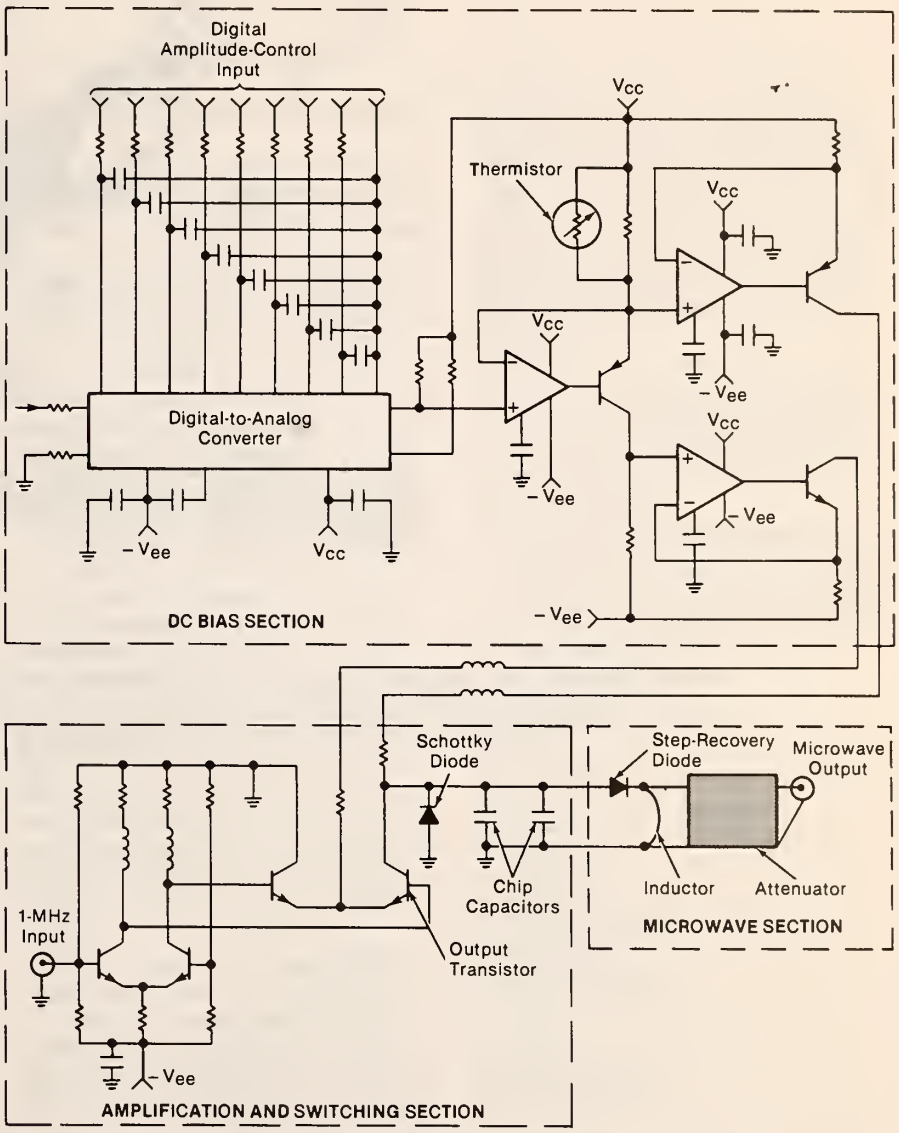



Figure 1. In the **Comb Generator**, a dc reverse-bias current is switched on and off at 1 MHz to generate sharp pulses in a step-recovery diode.

the chip capacitors is mounted in and connected across the loop.

*This work was done by E. H. Sigman of Caltech for* **NASA's Jet Propulsion Laboratory**. *NPO-17004/TN*

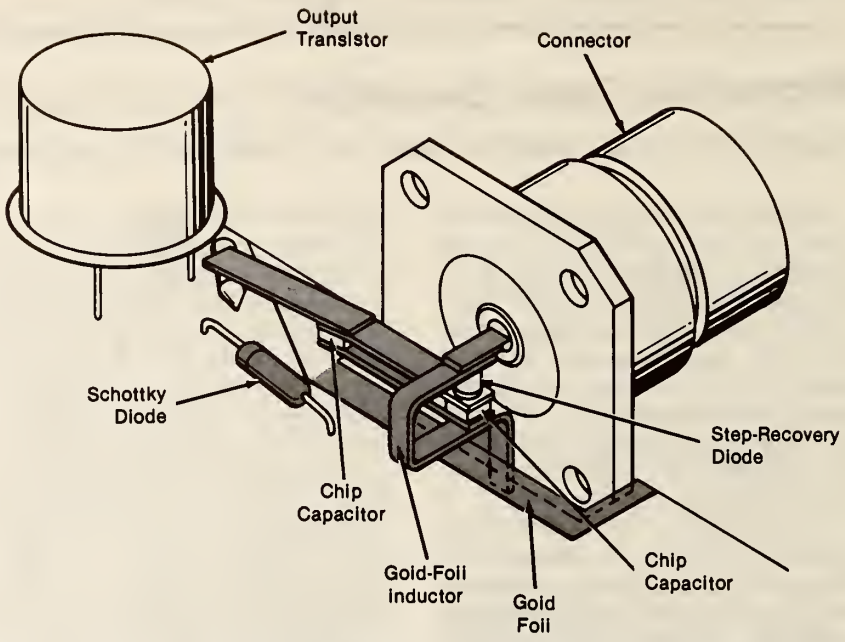



Figure 2. The **Microwave Components** of the comb generator are mounted on the back of a special connector that contains a built-in attenuator. The thickness of the inductor is shown exaggerated for clarity.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*

REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

Licensing Opportunity

# Automatic Frequency Control for DMSK Receiver

## Performance is analyzed theoretically and experimentally.

A report discusses the performance of the automatic frequency-control (AFC) subsystem of the differential minimum-shift-keying receiver described in "DMSK Receiver for Mobile/Satellite Service," NPO-16659, which appears in this issue of *NASA Tech Briefs*. It describes the efforts to quantify the behavior of the system during the acquisition of the carrier signal; these include a theoretical analysis leading to a numerical simulation, and measurements of the performance of the receiving equipment.

The AFC subsystem was added because the receiver has a small tolerance for frequency error. Since it has to operate in digital communications in which the data are transmitted in short bursts (packets), the receiver must be able to acquire quickly the carrier frequency of the transmitted signal. However, the design features that enhance rapid acquisition tend to degrade steady-state performance. Therefore, it is necessary to quantify the acquisition behavior of the AFC subsystem to optimize it for the intended signal parameters and receiving system.

The analysis begins with the input/output equations of the AFC loop, which is assumed to contain a resistor-and-capacitor low-pass filter. This is followed by a discussion of the nonlinear characteristic of the AFC loop, beginning with the sinusoidal dependence of the error voltage on a linear combination of the frequency error, the phase modulation due to intersymbol interference, and the phase modulation due to noise.

The report then presents a recursive equation that can be used to simulate numerically the performance of the nonlinear loop. A computer program based on this equation gives a sample of the output frequency of the voltage-controlled oscillator (VCO) of the AFC loop during a bit period. Next, an analysis of the steady-state behavior is based on the loop input/output equations and on the assumed loop-filter characteristics. The steady-state frequency error is shown to equal the difference between the input and VCO rest frequencies, divided by a closed-loop gain factor.

A numerical simulation was conducted for a system with a signal-to-noise ratio of 10 dB, a transmission rate of 2,400 b/s, a loop two-sided noise bandwidth of 34 Hz, a first-order loop filter with a time constant of 0.11 s, a loop-amplifier gain of 8, ideal bit synchronization, and an initial frequency error of 150 Hz. The simulated loop corrected for two-thirds of the initial frequency error in about 20 ms. By 40 ms, the error was down to about 20 Hz. The steady-state frequency error was 18 Hz (the predicted value was 16 Hz), with a standard deviation of 3.4 Hz.

A receiver with characteristics similar to those in the simulation was built and tested. The performance after acquisition times of 20 and 40 ms resembled the simulated performance. Bit-error measurements were also made and compared with theoretical values as functions of the signal-to-noise ratio. The 20-ms performance was about 0.7 dB inferior to the steady-state performance, which in turn was about 1.4 dB inferior to the ideal performance in the range tested. The theoretical pull-in frequency range of the AFC loop was 300 Hz, but noise reduced the range to 250 Hz.

*This work was done by Faramaz Davarian and Joe T. Sumida of Caltech for* **NASA's Jet Propulsion Laboratory**.

*"An Automatic Frequency Control (AFC) System for Minimum Shift Keying and Binary FM Signals,"*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL. Refer to NPO-17021/TN*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Power-Supply-Conditioning Circuit

Fluctuations of voltage are suppressed in power supplies for precise radio-frequency circuits.

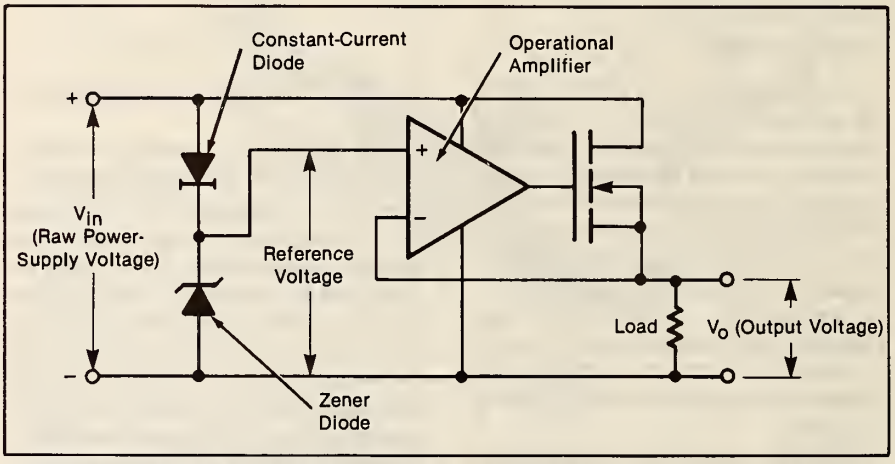
A power-supply-conditioning circuit suppresses both periodic and random deviations of dc supply voltage from the desired steady level. Essentially a highly-stable feedback voltage regulator, the conditioner is intended for use in conjunction with a conventional power-supply circuit to provide a more nearly constant voltage to an atomic frequency standard or other precise oscillator. Without such conditioners, the outputs of most commercial power supplies contain fluctuations that cause unacceptably-large phase and amplitude modulation of precise oscillators.

A voltage divider consisting of a constant-current diode and a Zener diode (or several Zener diodes in series) generates a reference voltage (see figure). Assuming that these two diodes are suitably matched for operation in their specified ranges of voltage and current, a fluctuation $e_i$ of the input voltage $V_{in}$ is suppressed in the output of the voltage divider by a rejection ratio of

$$e_o/e_i = r_z/(r_c + r_z)$$

where $e_o$ = the fluctuation in the output of the voltage divider, $r_z$ = the dynamic resistance of the Zener diode, and $r_c$ = the dynamic resistance of the constant-current diode. Representative values of $r_z$ and $r_c$ are 15 Ω and 50 kΩ, respectively, yielding a rejection ratio of about $3 \times 10^{-4}$.

The voltage reference operates at low current — typically, a few milliamperes. The rest of the circuit acts as a voltage follower; that is, a buffer between the high-impedance, low-current voltage reference and the high-current (typically as much as several amperes), low-impedance output. Feedback through the operational amplifier regulates the current through the field-effect transistor to reproduce the reference voltage at the output. With the proper selection of components, the voltage follower does not degrade the overall rejection ratio significantly.




A **Voltage Reference and a Feedback Voltage Follower** are combined to suppress fluctuations in the power-supply voltage.

The basic circuit concept can be varied to suit a given situation. For example, two such circuits can be concatenated to suppress fluctuations even further, and resistors and bypass capacitors can be added or deleted at various locations. A single-stage conditioner was built and tested by adding an alternating voltage to the raw power-supply voltage and measuring the alternating voltage at the output. The rejection ratio was found to vary from 73.5 dB at a frequency of 1 kHz to 51 dB at 10 kHz.

*This work was done by L. E. Primas and R. C. Loveland of Caltech for* **NASA's Jet Propulsion Laboratory**.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL*
*Refer to NPO-17233/TN*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Lyndon B. Johnson Space Center, Houston, Texas*

# Optimal Placement of Multiple Antennas

Obscuration by the structure or vehicle is taken into account.

A computer program based on a pair of algorithms selects approximately optimal locations of antennas and the approximately optimal number of elements in each antenna of a multiple-antenna communication system. Developed to aid in the design of the antenna system of a conceptual space station, the algorithms could also be applied to such a system aboard a ship or aircraft, on a building in a city, or in any location where transmission and reception are blocked in some directions from each potential antenna-mounting point.

The problem is to provide the required directional coverage of antenna radiation patterns with the minimum number of antenna elements. One way to solve this problem is to select the desired antenna positions, then compute and compare the directional coverages provided by all possible combinations of numbers of antenna elements and boresight angles (nominal aiming directions). This "brute-force" approach is exact but requires astronomical amounts of computing time in all but the simplest cases. The new program sacrifices some accuracy to yield solutions with a reasonable amount of computation.

The first algorithm begins with the analysis of the directions of obscuration at a given antenna position (see Figure 1). On the basis of the amount and direction of obscuration, the algorithm selects an initial boresight angle. Then, making an assumption about the radiation pattern of each element and the orientations of elements relative to each other, it computes the directional coverages of combinations of different numbers of elements (see Figure 2). Next, using a cost-versus-benefit function supplied by the user, the algorithm selects the number of elements to provide the best overall antenna-gain pattern in the unobscured directions.

The second algorithm begins by moving the boresight around the initial boresight angle in the search for a new boresight angle that yields better coverage. If such an angle is found, it is selected as the new boresight angle. The search is repeated until no other boresight yields better coverage. In practice, the angle that gives best coverage is usually found in a few iterations.

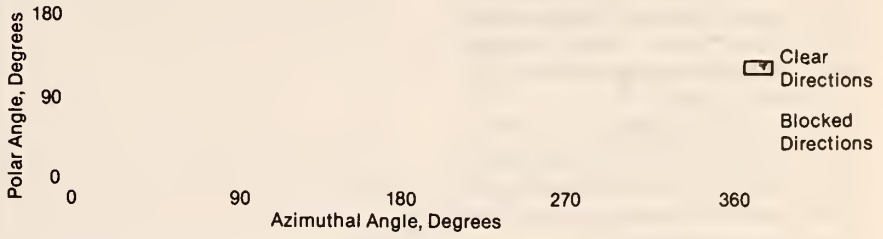



Figure 1. The **Obscuration in the Field of View** at a given antenna location is taken into account in the choice of the number of antenna elements to be mounted there.

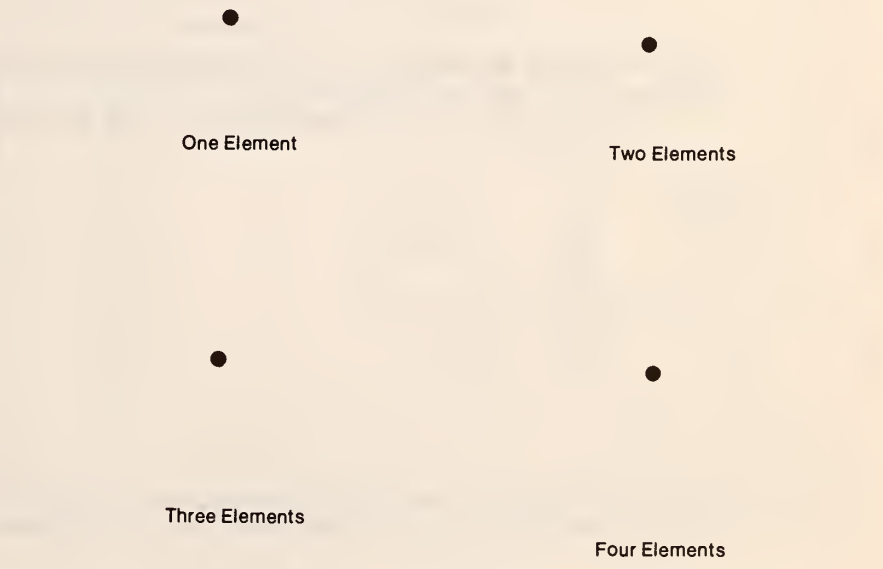



Figure 2. The **Directional Coverages** of combinations of as many as four antenna elements are computed in the search for a combination to cover the clear portion of the field of view.

The two algorithms are integrated to obtain the computer program, which finds the optimum positions of up to four antennas according to the following procedure:

1. Select a unique combination of locations available for the mounting of antennas.
2. Obtain the composite obscuration pattern for this combination.
3. From the list of available positions, select the one that offers the least obscuration.
4. Analyze the obscuration pattern for an initial boresight angle at this position.

5. Select the number of elements for this position.
6. Perform the iterative search for the best boresight angle.
7. Eliminate this antenna position from further consideration and return to step 3.
8. After all combinations of numbers of elements and boresight angles have been tested, obtain another unique set of available antenna locations and return to step 2.
9. After all unique combinations of available locations, numbers of elements, and boresight angles have been tested, select the one that yields the maximum coverage.

*This work was done by Kyle W. Shelton, Y. C. Loh, and K. Tu of Lockheed Engineering and Management Services Co. for* **Johnson Space Center**. *MSC-21291/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*

REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Lewis Research Center, Cleveland, Ohio*

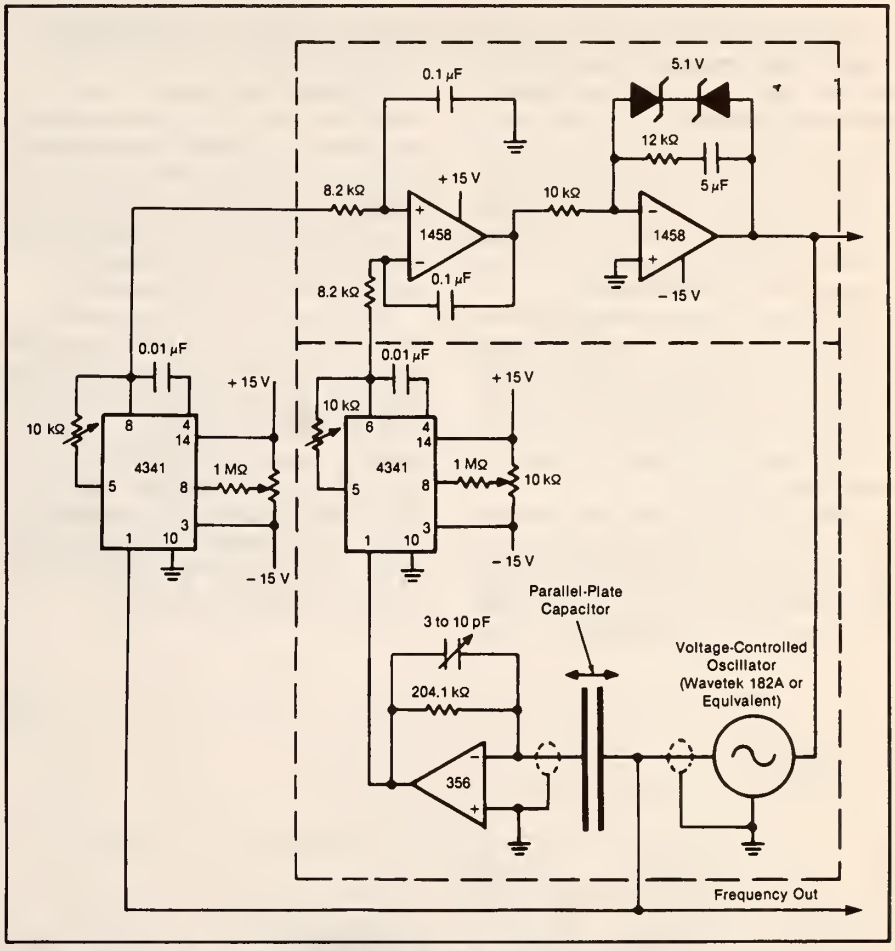
# Capacitive Displacement Sensor With Frequency Readout

The frequency varies approximately linearly with displacement.

A simple displacement-measuring circuit senses the capacitance between two parallel conducting plates and produces an output signal, the frequency of which is proportional to the distance between the plates. Capacitive techniques are often used to measure displacements. For example, such methods have been used to measure the displacement of a pressure-sensing diaphragm and to control the separation of two mirrors in an optical interferometer. The displacement-sensing principle of this circuit provides advantages over other methods because of its frequency-encoded output and high linearity.

The parallel-plate capacitor is made part of an operational-amplifier differentiator circuit (see figure). A voltage-controlled oscillator applies a sinusoidal signal to the capacitor. The voltage that controls the oscillator is supplied by a servocontrol circuit, which acts to adjust the frequency of the oscillator so that the rms value of the output of the differentiator is held fixed. This, in turn, causes the frequency of the oscillator to be proportional to the distance between the plates. With plates 25 mm in diameter, a linearity of 0.2 percent of full scale and a resolution of 10 nm were obtained for plate separations ranging from 0 to 5 mm.

*This work was done by Klaus Fritsch of John Carroll University for* **Lewis Research Center**. *No further documentation is available.*
*LEW-14792/TN*




The **Frequency of the Voltage-Controlled Oscillator** is nearly proportional to the distance between the plates of the parallel-plate capacitor for displacements up to 5 mm.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Low-Power Magnetic Current Sensor

Direct current is sensed via a saturable-core reactor.

A transducer senses a direct current magnetically, providing isolation between the input and the output. The detecting-and-isolating element is a saturable reactor, in which the input current (that is, the current to be measured) passes through a one-turn control coil. The transducer provides an output of 0 to 3 Vdc for an input current of 0 to 15 Adc and consumes a power of 22 mW at 10 Adc input.

Line driver $U_1$ excites the saturable reactor $L_1$ by feeding a 2.3-kHz square wave through transformer $T_1$ (see figure). The output of $L_1$ is rectified by the bridge rectifier composed of diodes $D_3$ through $D_6$, then amplified by operational amplifier $U_2$, which has a gain of 20.

Diodes $D_1$ and $D_2$ commutate the reactive current fed back to the primary of $T_1$ from $L_1$. Without these diodes, large reactive voltage spikes on the primary would waste power and could destroy $U_1$. Filter capacitor $C_1$ stores the energy fed back through $D_1$ and $D_2$.

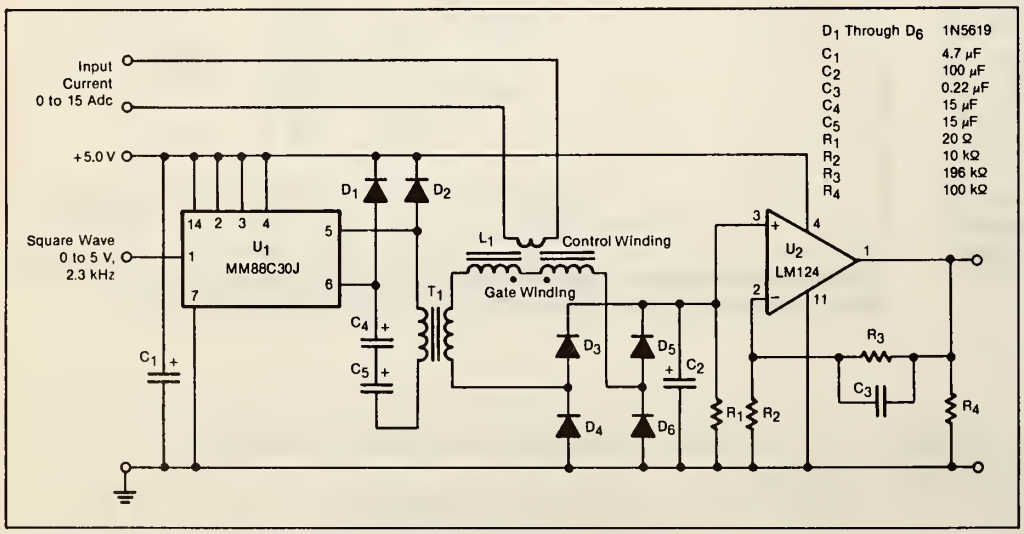
To minimize core losses, the core of $T_1$ is made of an alloy of 80 percent nickel/20 percent iron. To minimize capacitance, the primary and secondary windings are interleaved and progressively wound 350°. The primary and secondary windings consist of 408 and 660 turns, respectively, of No. 34 wire [6.3 mils (0.16 mm) in diameter].

The current in the gate windings of $L_1$ was specified to be 10 mA to keep the power consumption low. $L_1$ comprises two opposing gate windings of 1,500 turns each. To minimize capacitance, each was made by winding 750 turns of 350° progressively, applying insulation, then winding another 750 turns of 350° progressively rotated 180° from the first winding. The cores are matched and made of the same material as that of the core of $T_1$.

$U_1$ is a dual differential line driver that provides sufficient power to drive $T_1$. $U_1$, being a dual element, can be designed to self oscillate and not require synchronization at pin 1. If U, is used as an oscillator, then $C_4$ and $C_5$ can be omitted. $U_2$ was chosen because its input common-mode voltage includes ground and its output voltage can swing to ground during operation from a single power supply.

*This work was done by Colonel W. T. McLyman of Caltech for* **NASA's Jet Propulsion Laboratory**.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL*
*Refer to NPO-16888/TN*




The **Low-Power Current Transducer** provides an output voltage of 0 to 3 Vdc nearly proportional to the input current of 0 to 15 Adc. Because the input is sensed magnetically, the output is electrically isolated from the input.

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# Energy

0546 Improved Planning Methods for Electric Utilities

0548 Stable, Efficient Thin Film Solar Cell Developed

0549 Endurance Tests of Amorphous-Silicon Photovoltaic Modules—Failure mechanisms in high-power service are studied.

*Testing & Instrumentation*

0550 New Apparatus Measures Insulation Conductivity

*Oak Ridge National Laboratories*

# Improved Planning Methods for Electric Utilities

DOE manages a program on least-cost utility planning. This program develops and disseminates information on better ways for electric utilities to prepare long-term resource plans. It emphasizes the availability of conservation and load-management programs as resources that utilities can purchase, much as they can build power plants and buy power from other utilities and from independent power producers (Fig. 1).

In late 1985, ORNL staff visited utilities throughout the United States to learn about state-of-the-art efforts to plan and implement conservation and load-management programs, and to establish integrated resource planning processes. The experiences and insights gained by these utilities are summarized in the ORNL report *Electric Utility Demand Side Programs and Integrated Resource Planning: Visits to Ten Utilities.*

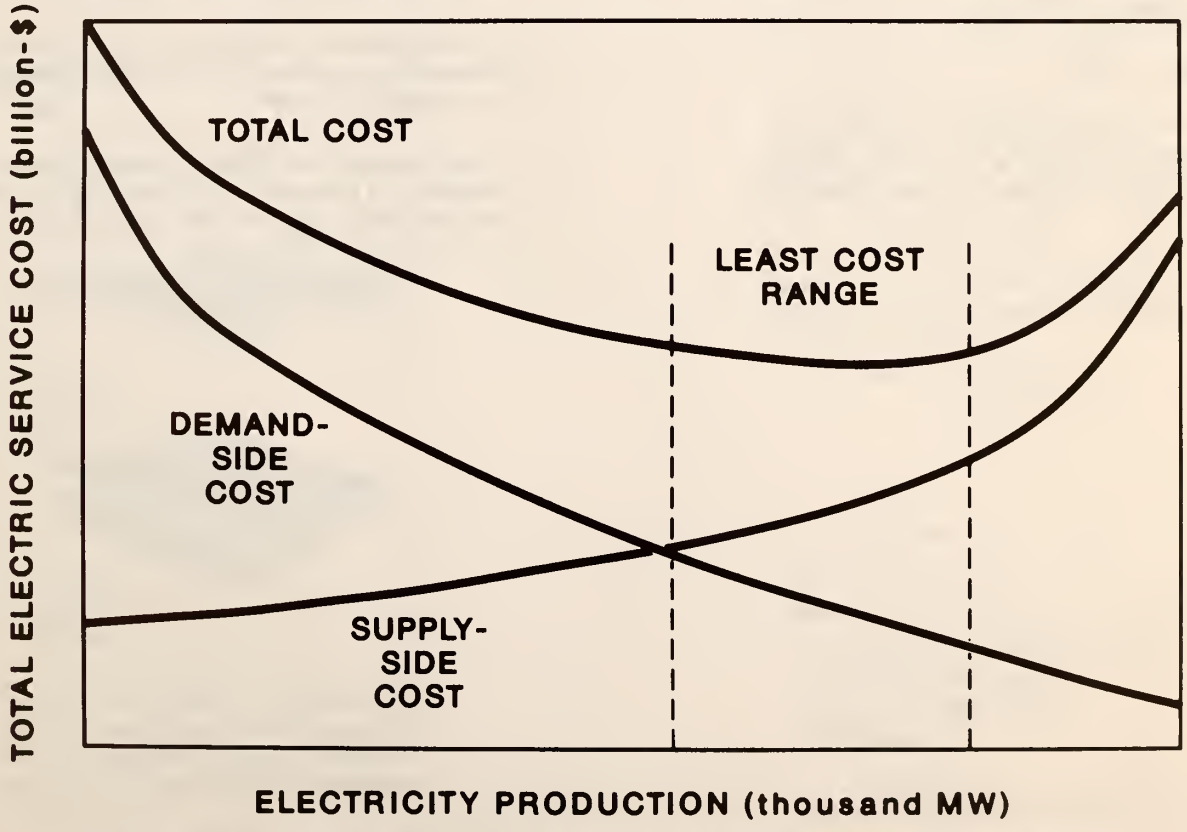



**Fig. 1. A least-cost energy plan is one output from a utility's integrated resource planning process. Such a plan combines demand-side and supply-side resources (as well as rate-design alternatives) to provide desired energy services to customers at low cost. A least-cost range is shown rather than a single point to emphasize the importance of uncertainty about different resources and the utility's external environment.**

Two related reports on electric-utility planning were published in January 1988. *Developing an Integrated Planning Process: An Electric Utility Case Study,* contains a discussion of development of the planning process at Puget Power, a medium-sized utility in western Washington. Puget Power's Demand and Resource Evaluation Program was initiated in February 1986; the final report was submitted to the Washington Utilities and Transportation Commission in November 1987. The objectives of Puget Power's plan, planning process, planning activities, and the significance of these objectives for other utilities and commissions are discussed.

*Regulatory Responsibility for Utility Integrated Resource Planning* addresses several issues that public utility commissions should consider as they develop the planning rules in their state. These issues include prudency reviews, economic tests for assessing demand-side programs, inclusion of marketing and competition in least-cost plans, treatment of uncertainty, inclusion of nonenergy factors, and commission staffing.

A fourth report, *Marginal-Cost-of-Service Analysis: A Powerful Marketing Tool for Electric Utilities,* was published in February 1988. This report shows how traditional cost-of-service analysis can be used to examine utility profitability—the difference between marginal revenues and marginal costs. Such analysis, coupled with market research information on customer preferences and electricity-use patterns, can be used to design demand-side programs that improve customer service and reduce electricity prices.

***Additional information:***

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

E. Hirst, *Electric Utility Demand Side Programs and Integrated Resource Planning: Visits to Ten Utilities,* ORNL/CON-195, Oak Ridge National Laboratory (March 1986).

E. Hirst and C. Knutsen, *Developing an Integrated Planning Process: An Electric Utility Case Study,* ORNL/CON-247, Oak Ridge National Laboratory (January 1988).

E. Hirst, *Regulatory Responsibility for Utility Integrated Resource Planning,* ORNL/CON-249, Oak Ridge National Laboratory (January 1988).

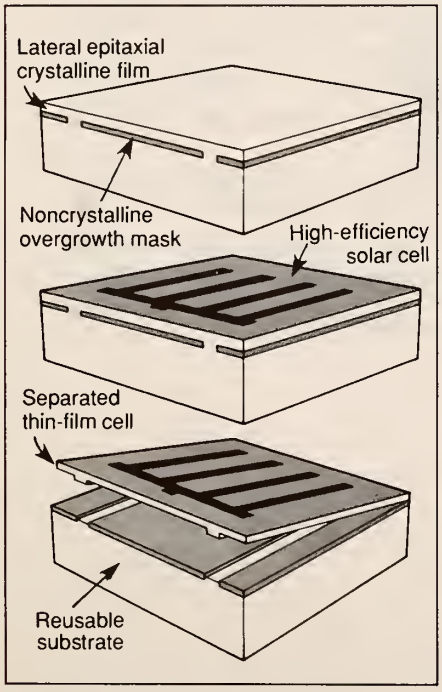
E. Hirst, *Marginal-Cost-of-Service Analysis: A Powerful Marketing Tool for Electric Utilities,* ORNL/CON-251, Oak Ridge National Laboratory (February 1988).

*Solar Energy Research Institute*

# Stable, Efficient Thin Film Solar Cell Developed

Stability, high efficiency, low cost. A photovoltaic module must have all three in order to compete with conventional electricity. Kopin Corporation, under subcontract to SERI, has achieved two of the requirements and is working on the third.

Kopin has developed a stable, 22.4% efficient thin-film solar cell and now is developing a large-scale, low-cost process for manufacturing modules.




*The Kopin process uses a bulk single-crystal "mold" to provide orientation for growth of the GaAs thin film. The film is largely processed into a solar cell before being separated from the mold.*

The approach taken by Kopin is quite different from that pursued by other thin-film manufacturers. The highest efficiency solar cells available today are made of high-quality, single-crystal gallium arsenide (GaAs). Typically, thin-film materials take on either the polycrystalline or amorphous form. Kopin's challenge was to determine if high-quality, *single* crystals could be obtained in thin-film form. The results show that the thin-film cell can duplicate the best performance achieved in traditional single-crystal technology.

Kopin has also shown that these stable, efficient thin-film cells can be monolithically interconnected on a single glass cover, a key cost-saving feature in the manufacturing process. Now, the engineering trade-offs between processing costs and product performance can be made knowledgeably so that large-scale, low-cost manufacturing can become a reality.

Contact: John Benner
(303) 231-1396

*For Additional Information:*

Mr. Dana Moran
Research & Technology Application
Solar Energy Research Institute
1617 Cole Boulevard
Goldon, CO 80401-3393
(303) 231-7115

Refer to Volume X, Number 3/TN

NASA Tech Brief
National Aeronautics and Space Administration

# Endurance Tests of Amorphous-Silicon Photovoltaic Modules

## Failure mechanisms in high-power service are studied.

A report discusses the factors that affect the endurance of amorphous-silicon solar cells. The report is based on field tests and accelerated aging of photovoltaic modules. The report concludes that aggressive research is needed if amorphous-silicon modules are to attain a 30-year life — the value that the U.S. Department of Energy has established as a goal for photovoltaic modules in commercial energy-generating plants.

Research topics of high priority include the following:

- Defects induced by light that degrade the outputs of photovoltaic cells;
- Corrosion of cells and the increased series resistance that results;
- The breaking strength of glass for large modules; and
- The development of protective encapsulants to prevent weathering and maintain high-voltage isolation.

Amorphous-silicon modules from leading manufacturers were subjected to standard qualification tests. They were also aged in the field under ambient conditions and at fixed temperatures of 70, 85, and 100 °C. They were given long-term tests at a temperature of 85 °C and relative humidities of 5 and 85 percent with various bias voltages, and they were subjected to laboratory tests for hotspots and corrosion. The overall method followed that developed earlier for crystalline-silicon modules. The researchers found that although the qualification tests for crystalline-silicon modules are useful, they do not excite the principal mechanisms that degrade amorphous-silicon modules.

The following failure mechanisms were evaluated: open circuits between cells, short-circuited cells, effects induced by light, gradual loss of power in cells, optical degradation of modules, front-surface soiling, breakage of glass in modules, open circuits between modules, hotspots in modules, failures of bypass diodes, short circuits between modules and ground, and delamination of modules.

*This work was done by Ronald G. Ross, Jr., and Russell S. Sugimura of Caltech for* **NASA's Jet Propulsion Laboratory**. *"Long-Term Experimental Testing of Silicon Modules,"*

*NPO-17304/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## New Apparatus Measures Insulation Conductivity

NIST researchers have developed an improved instrument for measuring thermal conductivity of insulation used in the chemical process and building construction industries. Termed as automated guarded-not-plate apparatus, it meets the requirements of ASTM Standard Test Method C-177 for measuring the thermal conductance of thermal insulation and covers a range from room temperature to 455°C (850°F) and from ambient atmospheric pressure to vacuum. It has an accuracy of 1.5 percent at room temperature and 2.5 percent at 455°C. It can be used to test insulation used in home construction, refrigerators, freezers, and some industrial applications such as ovens or steam lines in electrical power and chemical processing plants. Controlled by a scientific desk-top computer, this apparatus also gives a quick response during the initial control transient and high stability of the controlled temperatures at the final control conditions.

FOR ADDITIONAL IFNORMATION: A detailed explanation is available in An Automated High-Temperature Guarded-Hot-Plate Apparatus for Measuring Apparent Thermal Conductivity (NBSIR 88-3089). Order by stock number PB88-242060/NAC from the National Technical Information Service, Springfield, VA 22161, for $19.95.

# Engineering

0551 Reliability Engineer's Toolkit

0552 R, M & S Standards Primer: Guidelines for DOD Reliability, Maintenance, and Safety Standards

0553 Relief Valve for Superconducting Magnets

0554 Method Developed for Curing Patches on Contoured Surfaces

0555 Extension for Abrasive-Jet Cleaning—Hard-to-reach places can be cleaned more easily. (Licensing Opportunity)

0556 Modeling Plants with Moving-Average Outputs—Three discrete-state-variable representations are derived.

0557 Numerical Solution of Navier-Stokes Equations—Three-dimensional, incompressible flow is simulated on a computer.

0558 Plating Patches on Heat-Exchanger Jackets—Permanent repairs are made without welding. (Licensing Opportunity)

0559 Shock-Induced Heating in a Rocket Engine—Misalignment can give rise to hotspots on walls.

0560 Tethered Remote Manipulator—Potential advantages include safety and long reach. (Licensing Opportunity)

0561 Two-Thumbed Robot Hand—A middle finger and two thumbs would grasp and sense the shapes of a variety of objects. (Licensing Opportunity)

*Testing & Instrumentation*

0562 Turbulence within the Walls

0563 Constructing R-Curves from Residual-Strength Data—Old data can be exploited in a new concept.

0564 Fiber-Optic Sensor Would Detect Movements of Shaft—Magnetic inserts are not required.

0565 Detecting Residues on Grit-Blasted Surfaces—Fluorescent or iridescent additive would reveal unwanted deposits. (Licensing Opportunity)

*Other Items of Interest*

0550 New Apparatus Measures Insulation Conductivity

0566 Grout Fixation of Variable Phosphate/Sulfate Waste

0578 Better Sheet Metal Products with Less Waste

0615 Evaluation of Railroad Tracks

# Technology Assessment
## U.S. Air Force

---

## Reliability Engineer's Toolkit

Rome Air Development Center (RADC) has developed and published an application oriented guide for the practicing reliability engineer entitled "RADC Reliability Engineer's Toolkit." This 200+ page document was written by several members of the Systems Reliability and Engineering Division based on their combined experience in developing R&M techniques and in providing R&M engineering support to Air Force system development programs. The main sections of the document follow the flow of a normal development program, from determination of requirements to testing. Twelve appendices give a greater level of detail to some of the topics in the main sections and also provide useful reference materials. Examples of the subjects addressed are:

- R&M Task Priorities
- Part Stress Derating
- Design Review Questions
- Critical Item Checklists
- Reliability Prediction Methods
- Redundancy Equations
- Reliability Demonstration Plan Selection
- Warranty Guidelines
- R&M Data Sources
- R&M Education Sources
- AF R&M Focal Points

While the Toolkit's title says its content is reliability, a broad interpretation of the term has been taken to include maintainability and testability. Emphasis is on what the engineer's role is in the particular process. For example, what issues should be raised at design reviews, and what is the significance of contractor response?

FOR ADDITIONAL INFORMATION: A copy of the Toolkit may be obtained by written request to RADC/RBER, ATTN: RADC Toolkit, Griffiss AFB, NY 13441-5700.

# Technology Assessment
## U.S. Air Force

## R, M & S Standards Primer: Guidelines for DOD Reliability, Maintenance, and Safety Standards

Today's defense contractor is responsible for compliance with a vast array of military specifications, standards and handbooks. It is often difficult to determine those which most adequately address the Reliability, Maintainability and Safety (R, M & S) requirements of a given program without spending a great deal of time, effort and dollars. To simplify this task, the Reliability Analysis Center has published "R, M & S Standards Primer: Guidelines for DoD Reliability, Maintainability and Safety Standards (PRIM-1)."

Each chapter of this 400-page publication deals with a single standard, specification or handbook. It gives a brief description of the document, describes its purpose, explains its significance to the program and/or phase of the program, lists any applicable Data Item Descriptions (DIDs) and gives a brief explanation of how the document should be used. It explains how to tailor the document's requirements and also identifies those documents which may be unique to a specific branch of the military.

PRIM-1 provides the user with a single reference guide to the applicability and use of the most pertinent R, M & S military documents. This publication eliminates the necessity of having to order and review each document separately to determine its applicability to a specific program. This is especially helpful in proposal efforts if the user is not familiar with all of the R, M & S specifications or government procurement programs.

PRIM-1 is available from the Reliability Analysis Center, prepaid at $95 U.S. and $115 Non-U.S.

*For Additional Information, contact:*

Reliability Analysis Center
P.O. Box 4700
Rome, NY 13440-8200
(315) 330-4151

Department of Energy

Technology Application

*Fermi National Accelerator Laboratory*

# Relief Valve for Superconducting Magnets

The Collider Detector at Fermilab (CDF), now operating at the unexplored frontiers of high-energy physics research, has been the breeding ground for numerous technology coups. Among them is a relief valve that relates generally to a pressure-relief device for a vessel, and more particularly to a resealing pressure device valve for the vacuum vessel of superconducting magnets.

CDF utilizes a superconducting solenoid to produce a horizontal magnetic field used to study collisions between protons and antiprotons in the TEVATRON accelerator. The vacuum vessel which houses the superconducting coil consists of two concentric cylinders, the walls of which are as thin as the design requirements will allow. Under normal design conditions, the vacuum vessel is a dewar; that is, the space between the two cylinders is a vacuum. Thus, the working pressures that the cylinder walls are designed for assume a vacuum between the two cylindrical shells. The maximum allowable working pressure (MAWP) for a cylindrical shell where the pressure is compressing the shell radially inward is much lower than the MAWP for a cylindrical shell of similar dimensions where the pressure is pushing the cylindrical shell radially outward. A loss of vacuum to the vessel may result in a higher pressure in the vessel than the ambient pressure, resulting in an inner compression of the inner shell. A pressure difference of as little as 3 psig would result in failure of the inner shell, leading to expensive repairs and/or replacement of damaged equipment.

A non-reclosing, weight-type pressure relief device has been built and used at CDF. Unlike similar commercially available relief devices, the valve developed at Fermilab provides redundant pressure relief capabilities in the event the first relief setting sticks.

It is projected that this relief valve will be of interest to manufacturers of very-low-pressure vessels where the consequences of a valve failure could have serious repercussions.

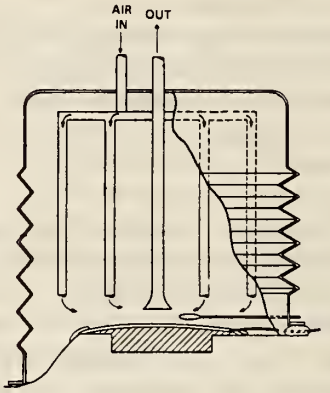
FOR ADDITIONAL INFORMATION: Office of Research and Technology Applications, Fermi National Accelerator Laboratory, P.O. Box 500, MS 208, Batavia, IL 60510; (312) 840-3333. Refer to FAA-355/TN.

NAVY
Domestic Technology Transfer Fact Sheet

# Method Developed for Curing Patches on Contoured Surfaces

Scientists at Naval Ocean Systems Center (NOSC), San Diego, California, have developed a method for curing patches on materials such as composite epoxy typically found in modern aircraft. Uniform heat can be applied to nonflat aircraft structures to cure repairs to composite material without having to remove part of the component from the aircraft.

A conformal oven is used having flexible sidewalls (preferably accordian shaped) that enable it to conform to and seal against a contoured surface. A vacuum is created within a vacuum sealing bag over the patch; then the oven is placed over the sealing bag and is sealed against the contoured surface being patched. A partial vacuum is created within the oven to maintain the seal against the contoured surface. The air within the oven is heated by force convection of air, electric heating, or other alternative heating means to cure the patch within the evacuated vacuum sealing bag.




*For Additional Information:*

Backup material on this effort is available from:

Navy Domestic Technology Fact Sheet Reader Reply Service
Code E211
Naval Surface Weapons Center
Dahlgren, VA 22448-5000
(703) 663-8921

Refer to 140104/TN

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

**Licensing Opportunity**

# Bendable Extension for Abrasive-Jet Cleaning

Hard-to-reach places can be cleaned more easily.

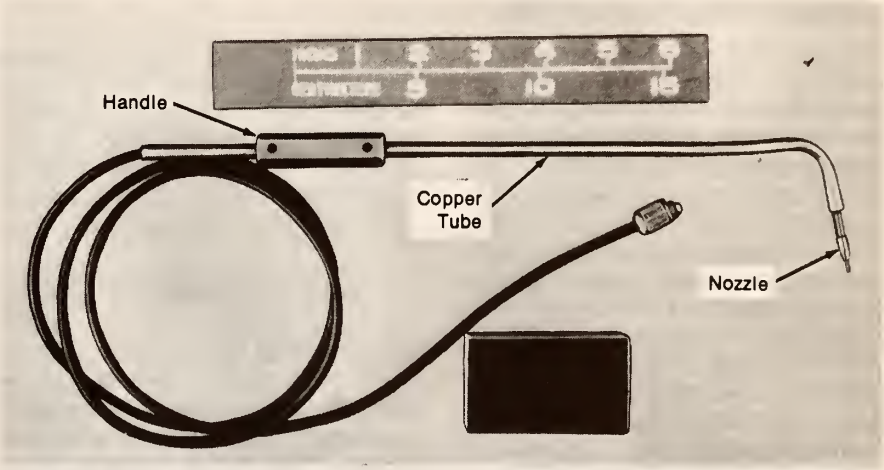
An extension for an abrasive-jet apparatus can be bent to provide controlled abrasive cleaning of walls in deep cavities or other hard-to-reach places. Designed for the controlled removal of penetrant inspection dyes from inside castings, the extension tube can also be used for such general grit-blasting work as the removal of scratches.

A bendable tube (see figure) is installed over a 3/16-in. (4.8-mm) diameter, neoprene extension hose that is part of a commercial abrasive-jet apparatus. Glass beads are pushed through the hose by a blast of air at a pressure of 80 psi (0.55 MPa). A standard carbide abrasive-jet nozzle with an inner diameter of 0.040 in. (1.0 mm) is installed in the hose at its outer end.

The tube, which is made of copper, has a ¼-in. (6.4-mm) outside diameter and is cut to the desired length. A ½-in. (12.7-mm) wide and 2-in. (51-mm) long, hexagonal brass handle is mounted on the tube with two setscrews. The hose is slipped through the tube until the nozzle protrudes at the outer end; then the tube is bent to the desired shape.

*This work was done by Walter Mayer of Rockwell International Corp. for* **Marshall Space Flight Center**. *No further documentation is available.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center. Refer to MFS-29298/TN*




A **Bendable Copper Tube** supports a commercial abrasive-jet extension hose. The abrasive jet was used to refinish the surface around the scribe line on the left side of the plate.

**George C. Marshall Space Flight Center**
*Technology Utilization Officer: Ismail Akbay*
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
*Patent Counsel:*
*Leon D. Wofford, Jr.*
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0024

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

## Modeling Plants With Moving-Average Outputs

Three discrete-state-variable representations are derived.

A paper discusses the mathematical modeling of digital control systems for plants in which the outputs include combinations of instantaneous and moving-average-prefiltered measurements. The author derives three discrete-state-variable representations of the behavior of a plant. An example illustrates how to obtain the coefficient matrices in each representation. Guidelines for the choice of the best representation for a plant are given.

The problem is to represent a plant operating in continuous time but driven by $r$ control inputs $\mathbf{u}$ fed through a zero-order hold of sampling period $T$. The plant has $m$ instantaneous outputs $\mathbf{y}_I$ and $q$ moving-average-prefiltered outputs $\mathbf{y}_F$, of sampling period $T$. The instantaneous state of the plant is represented by an $n$-dimensional vector $\mathbf{x}(t)$, where $t$ = time.

The derivation begins with the basic equations of state at the sampling instants. First, the analysis is applied to a simplified version of the plant with instantaneous output measurements only. Next, the analysis is extended to the fully complex version, in which an instantaneous $p$-dimensional output vector $\mathbf{z}(t)$ is moving-average sampled at a period of $T/N$, with sampling weights specified by coefficient matrices $H_j$ to produce the $q$-dimensional prefiltered output:

$$\mathbf{y}_F(kT) = \sum_{j=0}^{N-1} H_j\, \mathbf{z}[(k-j)\,(T/N)]$$

where $j$, $k$, and $N$ are integers.

The products of the analysis are three alternative sets of discrete-state-variable equations in matrix•vector form. The components of the vectors and matrices can be evaluated exactly by analytical or numerical means. These two representations enable the application of standard techniques to design a feedback controller for the plant. Without these representations, one would have to resort to approximate methods that would be less accurate or would consume much time if iterative.

In the first representation, the state vector of the overall system has $n+q$ dimensions; in the second representation, it has $n+r$ dimensions. If the moving-average-prefiltered output-measurement vector is modified by subtraction of a delayed and otherwise-prefiltered version of the input control vector, one obtains a third representation in which the state vector has $n$ dimensions and the equations of state are those of the simplified version of the plant. The author advises that, where possible, one should choose the representation with the smallest number of dimensions.

*This work was done by Michael E. Polites of* **Marshall Space Flight Center**. *Further information may be found in NASA TP-2732 [A02] "Modeling Digital Control Systems With MA-Prefiltered Measurements."*

*Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650.*
*Rush orders may be placed for an extra fee by calling (800) 336-4700.*
*MFS-27187/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

# Numerical Solution of Navier-Stokes Equations

## Three-dimensional, incompressible flow is simulated on a computer.

A report discusses the mathematical basis of the IN3SD computer code and the application of the code to several test problems. The code relies heavily on the use of pseudocompressibility to solve numerically the three-dimensional Navier-Stokes equations of viscous, incompressible flow. With further study and some modification, IN3SD promises to become a valuable computational tool for the solution of many engineering problems in fluid dynamics.

The formulation begins with the standard Navier-Stokes equations for the conservation of momentum in viscous, incompressible flow. The pseudocompressibility is introduced by replacing the incompressible-flow continuity equation $\nabla \cdot \mathbf{v} = 0$ with the equation

$$\frac{\partial p}{\partial t} + \beta \nabla \cdot \mathbf{v} = 0$$

where $p$ = pressure, $t$ = time, $\mathbf{v}$ = velocity, and $\beta$ = the pseudocompressibility parameter. The combined equations are placed in matrix/tensor form suitable for solution in general curvilinear coordinates adaptable to the configuration of the flow or boundary surfaces of the problem at hand.

The equations are advanced in time by the implicit, noniterative, approximately-factored, finite-difference scheme of Beam and Warming. The numerical stability of the scheme depends on the use of higher-order smoothing terms to damp out higher-frequency oscillations caused by second-order central differencing. The artificial compressibility introduces pressure (sound) waves of finite speed (whereas the speed of sound would be infinite in an incompressible fluid). As the solution converges, these pressure waves die out, causing the derivative of pressure with respect to time to approach zero. Thus, continuity is satisfied for the incompressible fluid in the steady state.

Because continuity is not satisfied until the steady state is attained, the solution does not give an accurate history of a flow that varies with time. However, the temporary relaxation of the requirement of continuity enables a significant reduction in the time required for the numerical simulation of the steady-state flow. Furthermore, the method of pseudocompressibility can be used to obtain at least a qualitative indication of the nature of an unsteady flow.

The report presents an analysis of the effect, on the calculations, of the use of different values of $\beta$. On the basis of this analysis, it presents guidelines for the proper choice of $\beta$ for fast convergence of the solution.

The code was tested on a steady, two-dimensional laminar flow over a backward-facing step; a steady symmetric, an impulsively started symmetric, and a vortex-shedding, nonsymmetric, perturbed, two-dimensional laminar flow around a cylinder; and a steady, three-dimensional laminar flow about a cylinder between two end plates. The numerical solution for the backward-facing step and the transient solution for the two-dimensional flow around the cylinder agreed well with experimental observations. The computed frequency of vortex shedding did not agree with the experimental value; this may be due in part to the fact that the calculations did not approach the steady state and the pseudo-pressure waves never died out. The three-dimensional solution showed a flow field with a saddle-point separation and a horseshoe-shaped vortex system, with secondary vortex filaments wrapping around the cylinder and spiraling up in the wake.

*This work was done by Stuart E. Rogers, Dochan Kwak, and James L. C. Chang of* **Ames Research Center.** *Further information may be found in NASA TM-86840* Price Code A03 *"Numerical Solution of the Incompressible Navier-Stokes Equations in Three-Dimensional Generalized Curvilinear Coordinates."*

*Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center*
*Refer to ARC-11794/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

**Licensing Opportunity**

# Plating Patches on Heat-Exchanger Jackets

Permanent repairs are made without welding.

A technique used to repair the nickel-alloy nozzle jacket of the Space Shuttle main engine (SSME) should also be applicable to other metal heat-exchanger jackets that have similar configurations. The technique does not require welding, brazing, soldering, or other operations that involve high temperatures and consequent damage to surrounding areas.

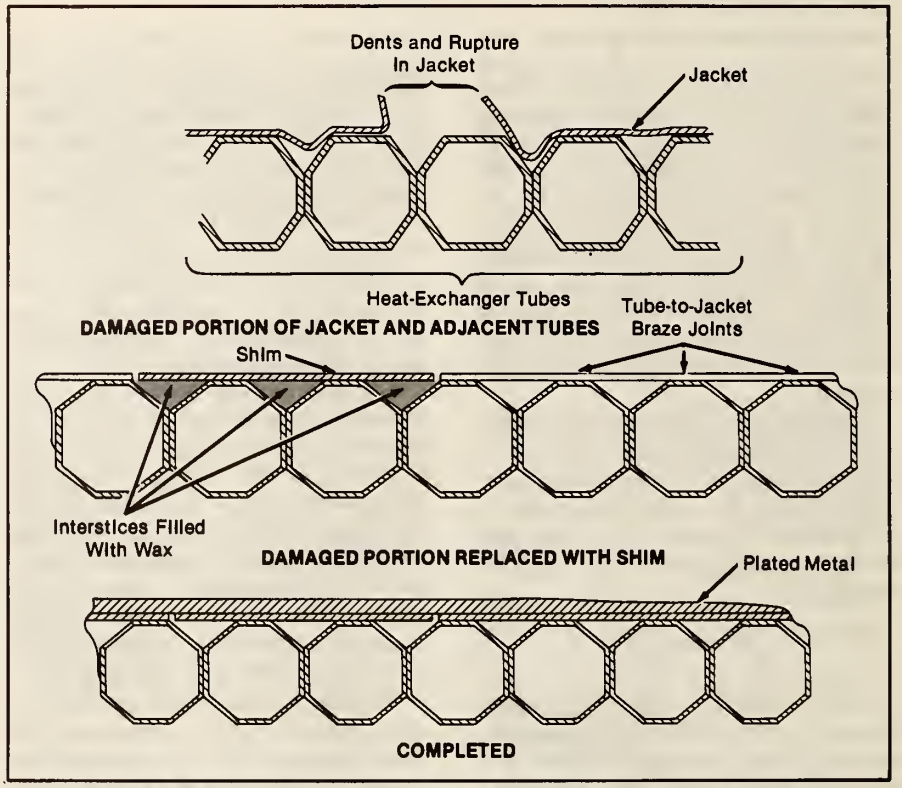
The portion of the jacket around a damaged area is removed by grinding and polishing out to edges adjacent to tube/jacket braze bonds (see figure). The spaces between tubes are filled with wax to prevent contamination of those spaces during subsequent plating.

A shim having the same thickness as that of the jacket [a nickel alloy 0.10 in. (0.25 mm) thick in the case of the SSME] is cut to replace the removed jacket material. After the shim is put in place, the shim and the adjacent area are plated (with nickel in the case of the SSME) to the required thickness [0.035 in. (0.89 mm) in the case of the SSME] at the center of the patch, tapering to 0.002 in. (0.05 mm) at the edge of the patch. The wax is then removed.

The maximum thickness of the plating in a particular case has to be determined by structural analysis to be sufficient to prevent the patch from buckling. The taper helps to maintain a smooth transition of stresses from the patch to the rest of the jacket. The edge of the patch is formed into a wave pattern to contribute further to a smooth transition of stresses.

*This work was done by Henry Loureiro and Frank Kubik of Rockwell International Corp. for* **Marshall Space Flight Center.**

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center. Refer to MFS-29345/TN*




**Metal Is Plated** over a shim that replaces the damaged portion of the jacket.

**George C. Marshall Space Flight Center**
*Technology Utilization Officer: Ismail Akbay*
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
*Patent Counsel:*
*Leon D. Wofford, Jr.*
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0024

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

## Shock-Induced Heating in a Rocket Engine

### Misalignments can give rise to hotspots on walls.

A report discusses a numerical simulation of the flow in and near a small, ringlike cavity in the wall of the Space Shuttle main engine at the junction of the main combustion chamber and the nozzle. The purpose of the simulation was to study the effects of misalignments between the combustion chamber and nozzle on the transfer of heat into the surfaces of the chamber, cavity, and nozzle. Depending on the specific misalignment, the flow could encounter a forward- or backward-facing step as it leaves the chamber and enters the nozzle. This could result in serious losses of performance and excessive heating of the walls.

The flow past the cavity includes complicated features like separation and reattachment of the boundary layer and interaction of the boundary layer with a shock downstream of the cavity. Consequently, analytical methods are inadequate to quantify the flow and temperature fields, and numerical simulation is essential. The mathematical model includes only local effects in a meridional-plane slice of the junction cavity and vicinity, and the flow is treated as two-dimensional in this plane. This computational domain is divided into two zones: the deepest portion of the cavity and everywhere else.

The steady, two-dimensional mean-turbulent-velocity and temperature fields are computed via a finite-volume code that solves the Navier-Stokes equations. The code uses total-variation-diminishing spatial discretization to capture shocks without producing unphysical oscillations in the solution. This feature is necessary for the accurate assessment of shock-induced heating downstream of the cavity. The Baldwin-Lomax model of turbulence is used to calculate the turbulent eddy viscosity. The previously-established boundary-layer profile on the wall of the combustion chamber at 109 percent power level is used as the inlet boundary condition, and a temperature of 913.5°R (507.5 K) is assumed for all solid surfaces.

The simulated flow separates from the wall at the upstream edge of the cavity and reattaches at the wall of the nozzle at a point downstream. A shock forms where the flow impinges on the wall downstream and interacts with the boundary layer near the point of reattachment. Upstream of the point of separation and downstream of the point of reattachment, there are fully-developed turbulent boundary layers.

In these upstream and downstream regions, the velocity profile is used to compute a wall shear stress, and then a Reynolds analogy is invoked to relate the wall shear stress to the flux density of heat. Because there is no boundary layer in the cavity, the flux of heat into the walls must be found by a different approach; namely, the calculation of the gradient of temperature in the wall by a second-order-accurate finite-difference approximation.

The results of the numerical simulation are given in contours of pressure, a map of velocity vectors, false-color maps of temperature and pressure, a plot of the flux density of heat as a function of position along the wall of the combustion chamber and the upstream wall of the cavity, and a similar plot of the flux density of heat along the downstream wall of the cavity and the wall of the nozzle. Among other things, the heat-flux plots show a severe rise at the shock. This prediction is confirmed by discoloration (due to overheating) of the wall downstream of the cavity of a test-fired engine.

*This work was done by Ronald R. Lagnado and Farhad Raiszadeh of Rockwell International Corp. for* **Marshall Space Flight Center**.

*"Analysis of Shock Induced Heating at the SSME Main Combustion Chamber/Nozzle Junction,"*
*MFS-29449/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

**Licensing Opportunity**

# Tethered Remote Manipulator

Potential advantages include safety and long reach.

A remote-manipulator concept proposed for the retrieval or inspection of objects in outer space could also be applied underwater or in tanks of hazardous chemicals. Called a "self-propelled line tether" or "space snake" by its inventor, the manipulator is intended for use in places beyond the reach of a jointed rigid-arm manipulator and where it is unsafe or impractical to send humans.

The system would include a tether head on the outer end of a tether cable wound on a motor-driven takeup reel. The head would include a mounting plate with four canted thrustors (i.e., nozzles) facing rearward, a solid-state camera with patterned sources of light facing forward, and a pneumatic inflatable end effector. The head could also include a device to cut the head loose in an emergency.

The tether cable would consist of a tubular outer section that encloses wires carrying power, control signals, camera signals, and the like between the tether head and the operator's control station. A video display at the control station would show the operator what the camera "sees." With this display as a guide, the operator would use a three-degree-of-freedom joystick to control the orientation and direction of forward motion of the head. This control action would produce the desired pitching, turning, or forward motions by selectively firing various combinations of the four thrustors.

The operator would use the reflected patterns from the sources of light as seen by the camera to maneuver the head into the final position to inspect or grasp the object. To grasp the object, the operator would inflate the remote manipulator. The object would then be retrieved by winding the cable onto the takeup reel. So that the operator could continue to control the motion of the head during retraction of the cable, the maximum takeup force of the reel would be less than the resultant thrust of the four thrustors.

The concept could be modified in any number of ways to suit specific situations. For example, the underwater version would be made neutrally buoyant and would be propelled by pressurized water instead of pressurized gas. The pressurized gas or pressurized water in the outer-space or underwater version, respectively, could be transported from the reel station to the head by a hose inside or alongside the tether cable. Alternatively, water could be pressurized by an electrically powered pump in the head of the underwater version, and the supply of gas could be mounted in the head of an outer-space version intended for brief use. Other options might include sensors to measure angles, forces, accelerations, positions, and distances; latches instead of or in addition to the powered remote manipulator; and additional thrustors for rolling and lateral translation.

*This work was done by Thomas C. Bryan of* **Marshall Space Flight Center.** *No further documentation is available.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center*
*Refer to MFS-28305/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Two-Thumbed Robot Hand

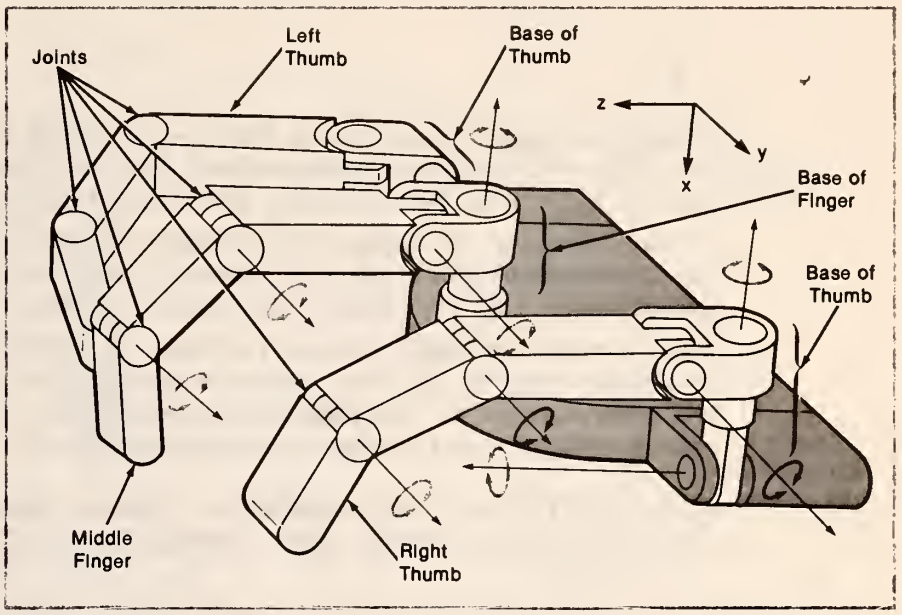
A middle finger and two thumbs would grasp and sense the shapes of a variety of objects.

A proposed robot hand would include thumblike members on its left and right sides and a fingerlike member at its middle. This configuration of digits would enable the hand to adapt to variously shaped objects, to grasp them robustly and reliably, and to manipulate them. It would also reduce the complexity of the control mechanisms and provide kinesthetic perception of the shapes of grasped objects.

Each thumb would have three rotational axes at its base joints and one rotational axis at each of its two other joints (see figure). The middle finger would have two rotational axes at its base joints and one rotational axis at each of its two other joints.

A dc-motor-and-gear assembly would rotate the thumb about the *z*-axis base joint to switch the whole thumb between upward-facing and downward-facing positions (this motion would not be provided for the middle finger). Another dc-motor-and-gear assembly would rotate the thumb or the center finger about the *x*-axis base joint, enabling adjustment of the yaw angle of the thumb or finger. A dc-motor-and-tendon connection would rotate a thumb or the middle finger about the *y*-axis base and other joints to control pitch angles and bending. Overall, the hand would have 14 joints controlled by eight motors: three motors for the yaw angles of the three members, two for the roll angles of the two thumbs, and three for bending the three members.

In a limited sense, the new hand could be considered anthropomorphic. It could be configured as part of a simulated human right or left hand or as overlapping parts of left and right hands. It could perform a wide range of grasping and manipulating motions. Moreover, the two thumbs would give the hand a mechanical symmetry and balance well suited to handling objects in industrial tasks.




The **Mechanical Hand** with two thumbs and a middle finger could be made from commercially available components. With specially designed dc motors and assemblies of gears, the size of the hand could be reduced considerably.

*This work was done by Sukhan Lee of the University of Southern California for* **NASA's Jet Propulsion Laboratory.**

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL*
*Refer to NPO-17274/TN*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## Turbulence within the Walls

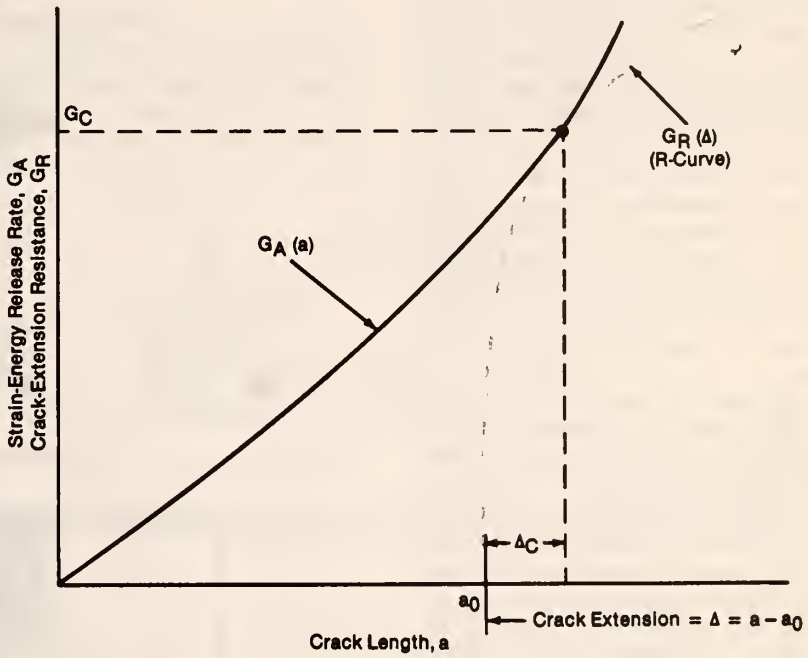
Turbulence inside pipes makes the measurement of fluid flow difficult. The cost of inaccurate measurements to the petroleum and chemical process industries, for example, can amount to hundreds of millions of dollars annually. Probing this problem, two NIST researchers in the Center for Chemical Engineering have come up with a strategy to predict meter performance for "non-ideal" installation conditions. Their research could yield a more practical process to check or calibrate an installed flowmeter by determining in-situ the profile of the pipeflow entering the meter. NIST has formed an industry-government consortium to sponsor this research program on flowmeter installation effects.

FOR ADDITIONAL INFORMATION: Contact George E. Mattingly, 105 Fluid Mechanics Building, NIST, Gaithersburg, MD 20899; (301) 975-5939.

NASA Tech Brief
National Aeronautics and Space Administration
*Lewis Research Center, Cleveland, Ohio*

# Constructing R-Curves From Residual-Strength Data

Old data can be exploited in a new concept.




**At the Critical Stress, the driving-force (strain-energy release rate) curve and the R (crack-extension resistance) curve are tangent. To the right of the point of tangency, the rate of release of strain energy exceeds the resistance to extension of the crack, and the specimen fractures.**

A method has been devised for estimating a crack-extension resistance curve (R-curve) from residual-strength data on precracked fracture specimens. The method enables the inference of additional information from simple test results, and that information can be used to estimate the failure loads of more complicated structures of the same material and thickness.

The R-curve is one of the most powerful concepts available to the fracture analyst. For a specimen or structure of the same material and thickness in the same environment as those of a specimen for which a stress-intensity analysis is available, the R-curve can be used to predict failure loads. Now, with the new method, it is possible to reverse the process; that is, given a curve of fracture strength versus original crack size, the R-curve can be determined. This means that data from simple residual-strength tests run many years ago can now be used to predict the failure loads of more complicated structures like reinforced panels or cracked holes of the same material and thickness. Such data may be found in the literature or may exist in company files.

The R-curve is developed from an analysis of the point at which the crack growth becomes unstable (see figure). First, at a given point on the residual-strength curve, a function that represents the square of the fracture stress, $\sigma_c^2$, and its derivative, are computed and substituted into an equation that must be solved (usually numerically) for the critical crack extension, $\Delta_c$. Then $\Delta_c$ and $\sigma_c^2$ are used to calculate the fracture toughness $G_c$. The pair ($G_c$, $\Delta_c$) define a point on the R-curve. The process is repeated to obtain additional points on the R-curve.

The new R-curve-estimation method has been tested in three applications:

1. Several semiempirical fracture analyses have been shown to be equivalent to particular R-curve formulations.
2. R-curves were estimated to a useful degree from published residual-strength data for a variety of specimen configurations.
3. The method was used successfully in an ASTM blind round-robin program.

*This work was done by Thomas W. Orange of* **Lewis Research Center**. *Further information may be found in NASA TM-87182 [N86-18750/NSP], Price Code: A02 "Estimating the R-Curve from Residual Strength Data."*

*Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-14592/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

# Fiber-Optic Sensor Would Detect Movements of Shaft

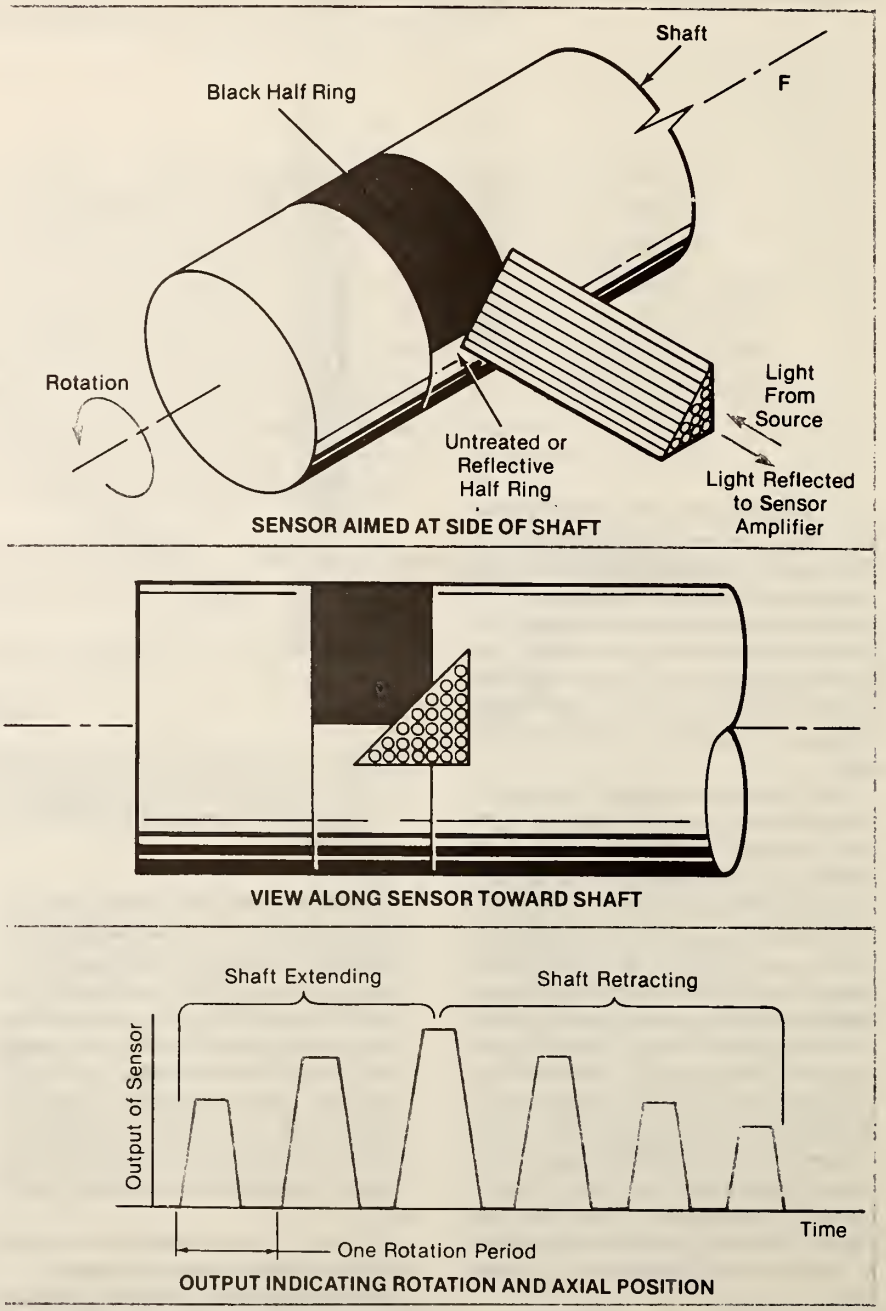
Magnetic inserts are not required.

A proposed fiber-optic sensor would sense both the rotational speed and the axial displacement of the shaft in a motor, pump, or other rotating machine. Unlike magnetic proximity sensors, this sensor does not require magnetic materials, notches, or grooves in the shaft. The only required modification of the shaft is etching or plating the surface (for example, with a black, microscopically rough coat of chromium) to make a ring that is black around half its circumference and reflective around the other half along a short length at one end or some other convenient location.

The fiber-optic sensor would include a bundle containing both light-sending and light-receiving fibers. At the probe end, the bundle would be formed into a triangular cross section, throughout which the sending and receiving fibers would be mixed evenly. The probe would be placed near the shaft, aimed perpendicularly to the axis of rotation, and positioned axially so that part of the black/reflective ring comes within the triangular field of illumination and view of the sensor (see figure).

With this arrangement, the amount of light returned from the probe and, therefore, the output signal of the sensor would vary with time as the black and reflective parts of the ring rotate past the probe. The rotational speed would thus equal the fundamental frequency of the probe-output pulses. Because the fraction of the triangle crossed by the black and reflective areas would vary with the axial position of the shaft, the amount of light and, therefore, the amplitude of the pulses would vary proportionally. Thus, the amplitude of the pulses could be used to infer the axial position of the shaft during operation.

*This work was done by Edmund J. Roschak of Rockwell International Corp. for* **Marshall Space Flight Center**. *No further documentation is available.*
*MFS-29382/TN*




**A Triangular Bundle of Sending and Receiving Optical Fibers** would be aimed at a black/reflective ring on a shaft. The frequency and the amplitude of the output pulses of the fiber-optic probe would indicate the rotational frequency and the axial position of the shaft, respectively.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

**Licensing Opportunity**

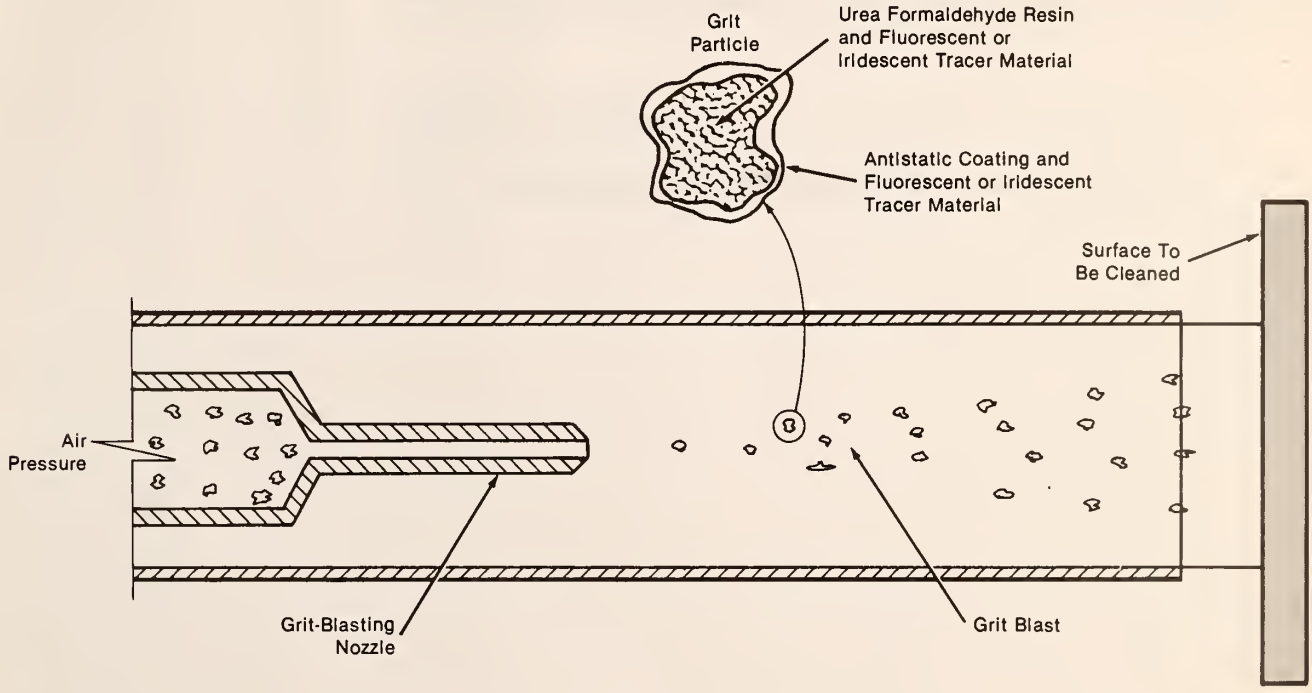
# Detecting Residues on Grit-Blasted Surfaces

Fluorescent or iridescent additive would reveal unwanted deposits.

The addition of a fluorescent or iridescent material to plastic grit particles has been proposed for the detection of grit residues after grit-blast cleaning. Residual films would be visible by observing grit-blasted surfaces under infrared or ultraviolet light.

The embedded residues, which are virtually impossible to detect otherwise, sometimes prevent the proper adhesion of paint or other coatings to grit-blasted surfaces. There is also evidence that the embedded grit and/or surface contamination may increase stress corrosion and reduce fracture strength.

The fluorescent or iridescent material would be added to both the urea formaldehyde grit particles and the monomolecular layers of antistatic material on the surfaces of the particles (see figure). The fluorescence or iridescence would not only reveal the presence of the residue but would also show, by increasing frequency of deposits, that the antistatic coating has been worn off much of the grit or that the grit is becoming too fine and should be replaced.


Grit Particle
Urea Formaldehyde Resin and Fluorescent or Iridescent Tracer Material
Antistatic Coating and Fluorescent or Iridescent Tracer Material
Surface To Be Cleaned
Air Pressure
Grit-Blasting Nozzle
Grit Blast

**Plastic Grit** would contain a fluorescent or iridescent additive in its core and its coating. Wherever the grit material became embedded, the additive would make it visible under infrared or ultraviolet light.

The concept may also be applicable to other grit materials. For example, the fluorescent or iridescent material could be added to particles of glass, silicon carbide, aluminum oxide, or zirconium silicate.

*This work was done by H. L. Novak and L. M. Zook of United Technologies Corp. for* **Marshall Space Flight Center**. *No further documentation is available.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18].Refer to MFS-28276/TN*

**George C. Marshall Space Flight Center**
*Technology Utilization Officer: Ismail Akbay*
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
*Patent Counsel:*
*Leon D. Wofford, Jr.*
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0024

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# Environmental Science & Technology

0566 Grout Fixation of Variable Phosphate/Sulfate Waste

*Testing & Instrumentation*

0568 Development of a High Volume Surface Sampler for Pesticides in Floor Dust

*Other Items of Interest*

0583 New Material Aimed at Measuring Workplace Dust

*Oak Ridge National Laboratories*

# Grout Fixation of Variable Phosphate/Sulfate Waste

Researchers in the Chemical Technology Division at ORNL have developed cement-based dry solid mixtures that produce processible, durable, and environmentally safe grouts when mixed with liquid radioactive waste. These mixtures were designed specifically for treatment of variable phosphate/sulfate waste streams in the Westinghouse Hanford Company Transportable Grout Facility (Fig. 1). They will be used as fixatives for a combination of two waste streams: decontamination waste (containing phosphates) and the ion-exchange regeneration waste (containing sulfate and sand filter sludge).

The researchers produced several useful formulas that contain varying ratios of Type III portland cement, class F fly ash, and two types of clay (Attapulgite-150 and Indian Red pottery clay). Fly ash, used as a cement extender, also improves the fluid properties of the grout and reduces the leachability of strontium. Attapulgite-150 primarily reduces drainable water from the product; when present at or above 0.7 lb/gal of waste water, it also appears to reduce leachability of the product. Indian Red pottery clay is added solely as an ion-exchange medium, primarily to retain $^{137}Cs$.

Certain blends were found to be optimal for certain waste concentrations and for certain mix-to-waste ratios. For example, 50 wt % of cement mixed with 28 wt % fly ash, 14 wt % Attapulgite-150 clay and 8 wt % Indian Red pottery clay produced acceptable grouts when mixed with 100% sulfate waste at mix ratios of 8, 8.5, and 9 lb/gal. This particular blend also produced acceptable grouts at concentrations of 25:75 and 75:25 phosphate:sulfate.

Chemical additives, added to the waste before mixing, aid the grouting procedure. For example, tributyl phosphate acts as a defoaming agent and helps reduce the entrainment of air in the grout during mixing. Aluminum phosphate reduces the amount of drainable water by promoting hydration. The growth of denser and possibly longer crystalline fibers during hydration helps to retain the hazardous waste constituents and radionuclides by reducing permeability of the grout.

The following tests were carried out on experimental grout samples:

- rheological measurements;
- flow consistency and flow behavior indexes;
- density;
- apparent viscosity;
- gel strength; and
- criteria based on federal regulations, such as unconfined compressive strength, drainable water, leachability index, and toxicity.

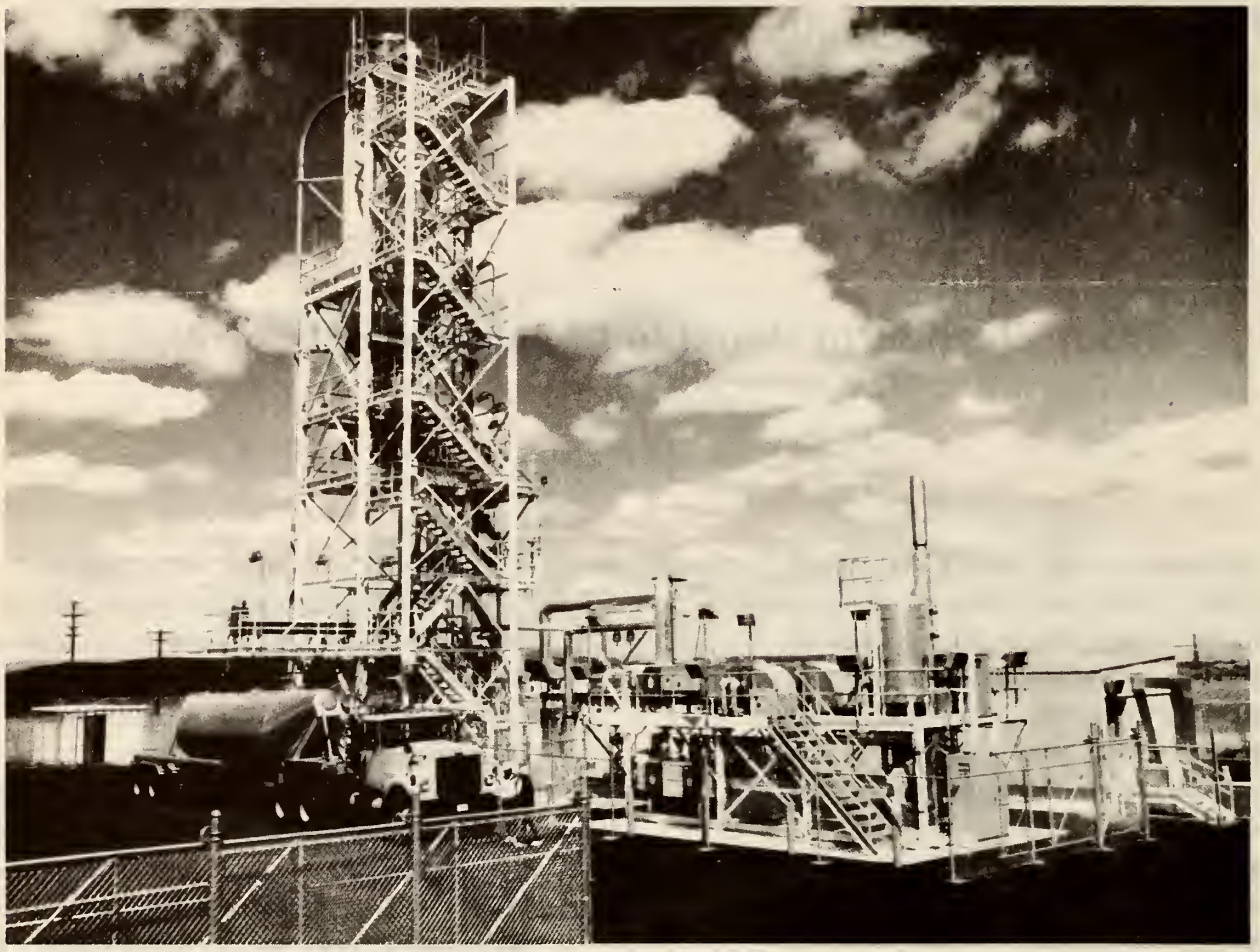


**Fig. 1. The Westinghouse Hanford Company Transportable Grout Facility. (Photograph courtesy of J. Everett, Boeing Computer Services, Richland, Washington.)**

### *Additional information:*

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

T. L. Sams et al., *Formulation Studies and Grout Development for Fixation of Variable Phosphate/Sulfate Waste, Milestone 195,* ORNL/TM-10291/R1, Oak Ridge National Laboratory (February 1988).

United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Research Triangle Park NC 27711

Research and Development

EPA

# Project Summary

## Development of a High Volume Surface Sampler for Pesticides in Floor Dust

**House dust and the pollutants carried with house dust are potentially important contributors to exposure through the pathways of inhalation, ingestion and skin penetration, especially for small children. Pesticides may be one of the more important contaminants of house dust.**

**A high volume surface sampler (HVS2) for the collection of house dust and the semivolatile organics in house dust has been designed and tested. The sampler consists of an intake nozzle, cyclone, and filter. The position of the nozzle is regulated by the static pressure in the nozzle. The HVS2 operates at approximately 9.5 L/s (20 cfm) and can collect more than 2 g of floor dust from a rug in an average clean residence in less than 4 min. Over 95% of the sample is retained in the cyclone and would, thus, be usable as a bulk sample for bioassays.**

**The HVS2 collects approximately 30% of the dust less than 150 μm from level loop and plush carpets. It collects 93.4% of the total dust from a smooth bare floor.**

**Previous studies of ambient sampling for pesticides suggested that semivolatile organics in house dust would not be retained on the filter and a polyurethane foam (PUF) absorbent would be necessary to collect them. Both house dust and a test dust were spiked with 10 or 20 ppm chlorpyrifos and dieldrin and 50 or 100 ppm diazinon. Virtually all the pesticide was retained in the cyclone or on the filter. Although a PUF filter does not appear to be necessary, it can be used with the HVS2.**

**Several alternative sampling methods were also studied. The collection efficiency for fine dust of conventional upright and canister-type vacuum cleaners, as well as small hand-held vacuum cleaners, was not sufficient and use as required here would have been difficult or impossible.**

*This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### Introduction

Recent studies of human exposure to air pollutants have increasingly recognized the importance of pathways other than inhalation. Ingestion of air pollutants deposited in water or on soil is potentially the source of a significant portion of an individual's total pollutant burden, especially for very young children, with their lower body weight and frequent hand-to-mouth activity. Dust can be both a medium for the transfer of pollutants from sources to people and a medium for the accumulation of pollutants. Failure to consider dust as a pathway for air pollution may result in a significant underestimation of health risks.

### *Analysis Procedures*

A size-specific efficiency was determined for the dust collection efficiency tests. The quartz fiber air sampling filters were desiccated to constant weight and weighed before and after sampling. Dust from the cyclone catch was weighed and sieved to determine the size-specific weight of the catch.

The size range that was found to be the most useful for analysis was for the material passing the 100 mesh (< 150 μm) screen. Thus, in each of the tests of dust collection efficiency the results are stated as a collection efficiency of fine materials, which is the percent of the total dust applied to the carpet that was recovered and passed the 100 mesh screen.

The fine materials (< 150 μm) applied to the carpet would, on average, be only about 20% of the total load. That means a reported 5% fines efficiency is

approximately equivalent to a 28% recovery of the applied fine materials.

Dust and vapors collected during the pesticide collection efficiency tests were analyzed for pesticide content by Environmental Monitoring and Services, Inc. Pesticide levels were determined by solvent extraction of the pesticides from the dust, filter, or PUF plug, reduction of the extract, and measurement by gas chromatography with electron capture detection. Both field blanks and method blanks were analyzed.

## Conclusions and Recommendations

The high volume surface sampler (HVS2) constructed by Cascade Stack Sampling Systems (CS3) is an effective and efficient way to collect samples of fine surface dust. A bulk sample of more than 2 g can be collected in about 4 min in an average clean residence.

The static pressure in the nozzle was found to be the best measure of the appropriate height for the nozzle on carpets. When operated at the defined optimal settings, the fine materials (less than 150 μm) collected from carpets by the HVS2 are approximately 6% of the total load of a standard test dust and approximately 30% of the fine materials in the test dust. Better than 93% of the test dust is collected from a bare, hard surface.

Semivolatile organic materials on the test dusts were retained on the collected dust. Experiments with a test dust which contained organic material, elemental carbon, sand, and talc found that a polyurethane foam (PUF) absorbent filter was not necessary for collection of the three pesticides tested. When both house dust and the test dust were spiked with 10 or 20 ppm of chlorpyrifos and dieldrin and 50 or 100 ppm of diazinon, less than 0.1% of the pesticide was found on the PUF filter.

The HVS2 can be used to measure complex mixtures of metals, solids, and organics on a variety of surfaces. Perhaps one of the most obvious uses is in support of studies of the health effects of indoor air pollutants and studies of the relative importance of pollutant pathways. Outdoors, the sampler could be used to measure pollutant accumulations in potentially air-mobilized soil surfaces. This might be useful in investigations of the potential risks associated with fugitive dust from hazardous waste land disposal sites, for example.

A field test of the HVS2 would be an important next step for evaluating this instrument and the recommended procedures provided in this report. Because surface dust is an integrated record of the pollutants introduced into the air above the surface, it is important that such a field test include air sampling during a period before and between the collection of surface samples.

The size distribution of house dust, the size distribution of dust on the hands of small children, and the size of particles which pass the cyclone and are found on the HVS2 filter should all be measured in order to more properly characterize the results obtained from the HVS2.

Although the tests reported here support a conclusion that no PUF absorbent filter is required for some semivolatile organics, this should be confirmed for more volatile compounds. It is suspected that the same conclusion will be reached, as the more volatile compounds will also be less likely to be found in the dust.

While the tests of alternative procedures did not find a simple procedure which can meet the performance goals for the HVS2, an exploration of such methods should continue, perhaps with the goal of finding a screening method which would not yield data that meet rigorous standards but could be used inexpensively for large, preliminary samples.

J. W. Roberts and M. G. Ruby are with Engineering Plus, Seattle, WA 98122. Nancy Wilson, is the EPA Project Officer (see below). The cojmplete report, entitled "Development of a High Volume Surface Sampler for Pesticides in Floor Dust," (Order No. PB 89-124 630/AS; Cost: $15.95, subject to change) will be available only from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650. The EPA Project Officer can be contact at: Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

# Manufacturing, Machinery & Tools

0570 Abrasive Waterjet Cutting

0572 Evaluation of Explosion Welding for Repairing Aluminum Structures

0574 Hyper-Standard has Applications for PDES

0575 Generation Method Improves Spiral Bevel Gears—Conjugate tooth surfaces reduce kinematic errors.

0576 Making and Inspecting Large Wire Grids—Old techniques are refined and combined to make new polarizers

0577 New Methods for Generating Gear Surfaces—Conjugate surfaces can be generated and analyzed for a variety of useful configurations.

*Testing & Instrumentation*

0578 Better Sheet Metal Products with Less Waste

0579 Plug Would Collimate X Rays—A simple device would create a narrow, well-defined beam for radiographic measurements of thickness.

0580 Three-Dimensional Coaxial Weld Monitoring—Parallax would be incorporated into the optical system.

*Other Items of Interest*

0558 Plating Patches on Heat-Exchanger Jackets—Permanent repairs are made without welding. (Licensing Opportunity)

0588 Canning of Powered Metal for Hot Isostatic Pressing—The quality of the specimen is enhanced by and improved canning process. (Licensing Opportunity)

# U.S. Army Fact Sheet

U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260

## Abrasive Waterjet Cutting

The use of waterjet cutting dates back to gold mining in California in the 1870's, when it was used to move mountains of gold-laden earth. By comparison, the use of waterjets in a manufacturing environment is relatively new. Its history can be traced to a patent granted in 1968. Dr. Norman Franz, a professor of forestry at the University of British Columbia, Canada, was the first to develop a concept for a high pressure waterjet cutting system. He took his idea to McCartney Manufacturing, a subsidiary of Ingersoll-Rand and a manufacturer of high pressure intensifiers for the polyethylene industry. These intensifiers were capable of producing pressures of 50,000 psi, which Dr. Franz envisioned as a requirement for his new process.

The first waterjet cutting system was installed at Alton Box Board Company, Jackson, Tennessee, in 1971. The machine was used to cut five-foot-long paper tubes and to contour-cut 1/2-inch-thick laminated stock for furniture parts. Since its first application the use of high pressure waterjet cutting has become accepted as a standard cutting tool in a wide variety of industries. A few key industries in which waterjet cutting has been applied are aerospace, automotive, building products, electronics, food processing, pulp and paper, shoes and garment, sporting goods, defense, and disposable products such as baby diapers. However, waterjet cutting is limited to cutting materials characterized as fibrous, porous, granular, or soft.

A new process, "abrasive waterjet cutting", was created by the introduction of abrasive particles into the waterjet, greatly increasing capabilities. The addition of abrasives to the waterjet stream expands cutting capability to almost any material known to man and makes it one of the most versatile tools in use today. The technology of adding abrasives to waterjet cutting was successfully introduced into the marketplace in 1983. Flow Systems, Inc. entered the waterjet cutting market with a unit they installed to trim wet-lap mat subsequently pressed into hardboard. Abrasive waterjet is rapidly finding use in cutting hard, dense material such as glass, composites, metals, and fired ceramics. These materials are difficult to cut by older, conventional processes because they tend to fray, crack, splinter, shatter, or show heat effects.

The aerospace industry is the present leader in applying abrasive waterjet cutting and is posting three-fold production gains. Currently, the most cost effective applications are cutting composites for wings and body panels, wing stiffeners, and other high-stress parts. The automotive industry is already using waterjet cutting and will have an increasing need for abrasive waterjet cutting because of the increasing substitution of composite material for metal doors, hoods, dashboards, bumpers, and other truck and automotive parts. This will challenge the aerospace industry's lead in abrasive waterjet cutting because of the latter's large volume production and large capital expenditures.

Waterjet technology is also being successfully applied to mining, oil drilling, tunneling, concrete cutting, rock cutting, and cleaning, as well as factory manufacturing. The technology growth includes different types of waterjet: continuous, pulsed, and cavitational, with continuous waterjet being used for almost all active industrial applications.

*For Additional Information:*
Rolf Anderson
U.S. Army Industral Engineering Activity
Rock Island, IL 61299-7260
(309) 782-6586

US Army Corps of Engineers
**Facilities Engineering Support Agency**
Fort Belvoir, VA 22060

# Evaluation of Explosion Welding for Repairing Aluminum Structures

The Corps of Engineers has many aluminum items in its inventory, including waterborne vehicles and flotation devices. These items are subject to punctures that can compromise their watertightness. Corps personnel currently repair punctures by gas metal arc welding a patch over the hole, a sometimes difficult process that requires extensive welder training and qualification. An investigation was conducted at the Corps of Engineers Construction Engineering Research Laboratory to determine the feasibility of explosion welding aluminum patches to restore watertightness to damaged aluminum alloy structures. Acceptance criteria for the process included:

- Minimal gouging and denting of the aluminum structure
- A single repair system using existing technology that could be used in the field with flat and curved surfaces of 5456 and 6061 aluminum alloys
- Minimal quantity of explosive
- Safety and portability for easy application under field conditions
- Incorporation of explosives, including the detonator, that are standard materials currently used in the military, therefore meeting the required safety standards

The patch or cover sheet material selected for the repair procedure was 0.062-inch-thick 6061-T6 aluminum sheet [1 inch = 25.4 mm]. The aluminum alloy base materials and thickness used in the study were 0.125-inch-thick 6061-T6, 0.250-inch-thick 6061-T6 and 0.250-inch-thick 5456.

Initial experiments comprised linear welds along the centerline of 1.5-inch-wide by 6.0-inch-long by 0.125-inch thick 6061 to determine.

- The loading (grains per foot) of explosive cord
- The initial standoff distance
- The allowable variation in standoff distance between the cover sheet and the base material.

The weld integrity was evaluated by chisel testing to determine if the weld could be separated by peeling. Welds were successfully made using 50 grains/ft. explosive cord and a separation distance of 0.032 to 0.062 inch. The explosive cord was initiated with a standard No. 8 electrical detonator. In chisel testing, the cover sheet failed around the weld, leaving the weld intact. It also was found that the explosive cord required a backing material to cover it and the patch plate. Plaster of paris, which is readily available and can be poured into any shape, was used for this backing material.

Following the initial welding experiments, flat 4.5-inch-diameter circular patch welds were made with 6-inch-square, 0.062-inch-thick 6061-T6 patch plates, and 0.125- and 0.250-inch-thick 6061-T6 and 0.25-inch-thick 5456 base plates. The back surfaces of the base plates were supported with 2-inch-thick styrofoam resting on a steel anvil. Following welding, the area sealed by the ring weld under the patch was pressurized to 10 psi with through a predrilled and tapped hole in the base, and then checked for leaks while the specimen was held underwater. The total quantity of explosive required to make each of these welds was 4.1 grams, not including the detonator. No leaks were found in the three specimens that were tested. The largest depth of deformation of the base plate into the styrofoam support was 0.281 inch with the 0.125-inch-thick 6061-T6 base plate.

The size of the patch weld was increased to a 4-inch by 8-inch oval in the third set of experiments. Some of the base plates, 0.125- and 0.25-inch-thick 6061-T6, were supported by styrofoam, water or neoprene rubber; others were unsupported. Each weld was leak tested to a pressure of 10 psi. With no support, considerable deformation of the base plate occurred (1 inch with 0.125-inch-thick 6061-%6) so that the 0.125- and 0.250-inch-thick 6061-T6 were only partially welded. Using a 2-inch-thick styrofoam support, the maximum depth of deformation was less than 0.032 inch and the weld was sound. Adequate support also was provided by a minimum of 1 inch of water or 1/2 inch of neoprene rubber.

In the final tests, a 4- by 8-inch, 0.062-inch-thick patch was welded, using 6.5 grams of explosive, to a 0.25-inch-thick 6061-T6 base plate, both formed to a 4-inch radius. One-half- inch-thick neoprene rubber was reused to support the curved base plate. The parameters established in the initial linear welds were used. The finished weld did not leak at a test pressure of 10 psi.

It was recommended that a portable field unit be designed and deployed to include explosive cord, backing material for the base plate, backing material for the cord, detonators and cardboard to hold the backing material for the cord.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703)487-4600.

NTIS order number: AD-A193303/NAC

Price Code: A03

# Navy Manufacturing Technology

## Automated Manufacturing Research Facility

National Institute of Standards & Technology
Formerly the National Bureau of Standards (NBS)
U.S. Department of Commerce, Gaithersburg, MD 20899

## Hyper-Standard has Applications for PDES

Using a "hyparstendard" system daveloped by AMRF researchers, an implamantor of an information processing standard such as PDES (tha Product Deta Exchanga Spacificetion) cen saerch through tha stenderd, raleted rasearch pepars, public domain software, end libreries of elgorithms to locete tha informetion naaded to build a working system.

The proposad system combinas axisting computing technologias hypartaxt, CD-ROM storege, and documant processing.

Unlike e stenderds document which cen be comperad to an encyclopadia, e document in hypartaxt consists of a collection of "intarconnactad writings" stored in nodes connacted by links. Using tha HyparCard program, a hypartext anvironmant which runs on a Mecintosh personel computar and its programming languaga, HyparTalk, tha implemantor can browse through one section, come upon a point of interast, and follow that point along its links to othar (cross rafarancad) sactions in tha collaction of writings. Thasa "documants" ara not limited to taxt. Thay may includa graphics, eudio, and computar programs.

Tha CD-ROM (Compact Disc-Raad Only Mamory), an inaxpansiva mass storaga madium, will maka tha NIST hyparstandard systam practical. The CD-ROM is capable of storing 500 million bytes of information on a 5 1/2" lasar raadabla disk (idantical to CDs for home usa) thet may ba duplicatad in quantity for e cost of $2 to $5. The CD-ROM drives usad to raad tha data, function with parsonal computars, workstations, and mainframas and cost around $1000. Public domain software tools ambeddad in tha hyparstendard system allow it to also sarva as a softwara librarian.

PDES is an emarging information processing standard being used at NIST es the prototype for proof of concapt for this hyparstendard system. Stendards like PDES diffar from thosa in tha physical sciancas bacausa thara is no physicel antity associatad with tham. Thay ara papar documants creatad by thair sponsors and ara oftan long and difficult to understand. To implament tham corractly, prospectlve usars must interpret tham corractly.

Tha davelopmant of PDES is e complex and ambitious standards project in great demand by industry and DOD; however, its potantial implamantors ara baing prasantad with e confusing errey of possibilitias and problams.

A hyperstandard system such as tha one proposad by NIST can provide a rich anvironmant, complete with rasearch documants and software tools, in which to davalop, dissaminate, and implemant a standard such as PDES. A demonstration varsion is available, and a CD-ROM varsion of PDES will ba davaloped this coming yaar.

*For Additional Information:*

To discuss this effort further, contact:
Stanford Ressler
AMRF Project
Building 220—Room A-127
National Institute of Standards & Technology
Gaithersburg, MD 20899
(301) 975-3549

NASA Tech Brief
National Aeronautics and Space Administration
*Lewis Research Center, Cleveland, Ohio*

# Generation Method Improves Spiral Bevel Gears

Conjugate tooth surfaces reduce kinematic errors.

A method for the generation of spiral bevel gears provides conjugated gear-tooth surfaces and improved bearing contact. Conjugated surfaces are preferable because they maintain constant gear ratios during tooth-contact cycles. The changing gear ratios of nonconjugated surfaces give rise to kinematical errors in the transfer of motion from driving gears to driven gears; these errors are major sources of noise in power transmissions (see Figure 1).

The geometry and the generation of spiral bevel gears have been subjects of intensive research. The new generation method is the product of a research effort to eliminate kinematical errors and improve the conditions of lubrication and bearing contact. The new generation method can be practiced by using specially calculated settings on existing Gleason gear-generating machines and tools — an important advantage because such equipment can cut high-quality gears by milling or grinding. The resulting gears have localized bearing contacts, which are typical for Gleason gears and are necessary to reduce the sensitivities of gear-tooth-surface contacts to misalignments and deflections of gear shafts in operation.

The generation concept includes the requirement that the line perpendicular to the meshing gear teeth at the point of contact points in the same direction throughout the process of meshing. This is geometrically equivalent to the constant orientation of a link between two mating ellipses of different orientations and dimensions (see Figure 2). The new generation process causes the contact ellipse to move lengthwise along a gear tooth in the way that is most advantageous for lubrication.

A computer program has been developed to simulate the cutting and meshing processes for pinions and gears, to obtain numerical results to verify that the new generation concept minimizes kinematical errors. The program is based on the principle that, at the instantaneous point of contact between meshing teeth, the position vectors must agree, the equations for meshing between the generating and generated gears must be obeyed, and the lines perpendicular to the surfaces of the teeth must coincide. The outputs are the shapes of the gear teeth, the contact path, the kinematic error, and the contact ellipse between the mating gear teeth.

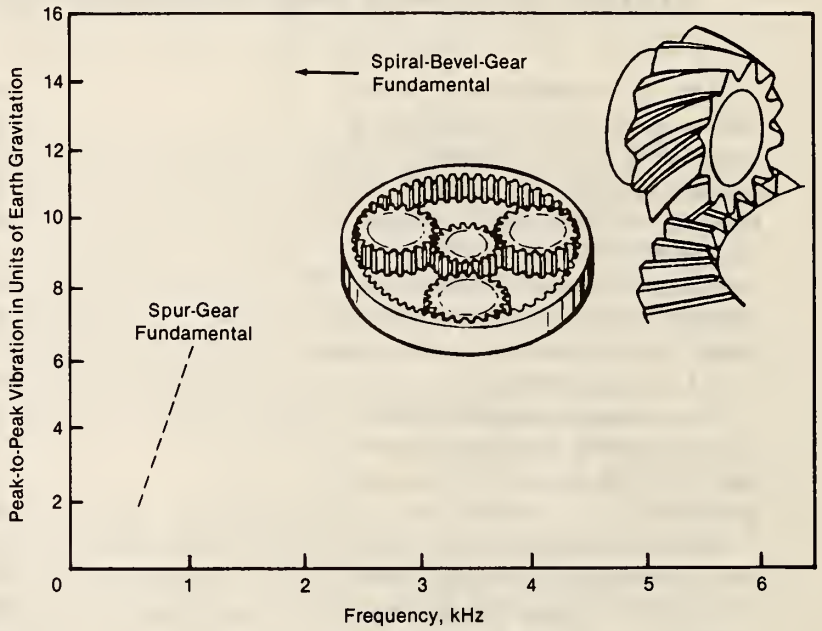



**Figure 1. The Vibration Spectrum** obtained by an accelerometer on the housing of a helicopter transmission shows that the spiral bevel gear caused the most noise and vibration.

The computer analysis was applied to a case in which practical considerations dictated the use of standard blade angles. With the new machine settings, the kinematical errors were very small (less than 0.02 arc seconds), whereas conventional settings yielded kinematic errors ranging from 20 to 90 arc seconds.

*This work was done by Faydor L. Litvin and Wei-Jiung Tsung of the University of Illinois at Chicago, John J. Coy of the U.S. Army Aviation Research and Technology Activity — AVSCOM, and Charles Heine of Dana Corp. for* **Lewis Research Center.** *Further information may be found in NASA TM-87273* Price Code A02 *"Generation of Spiral Bevel Gears With Zero Kinematical Errors and Computer Aided Tooth Contact Analysis."*

*LEW-14611*

*Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.*

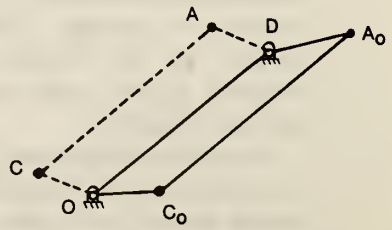



Figure 2. The **Basis for the Machine-Tool Settings** for the generation of conjugate spiral-bevel-gear tooth surfaces is the relation between mating ellipses. The ellipses are traced out by points C and A when the machine cradles rotate about their axes (which pass through points O and D). As it moves along the ellipses, link CA remains parallel to a fixed line $C_o A_o$.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Goddard Space Flight Center, Greenbelt, Maryland*

# Making and Inspecting Large Wire Grids

## Old techniques are refined and combined to make new polarizers

Equipment and procedures have been developed for the fabrication and inspection of large, precisely-spaced, flat grids of wire. Such grids are useful primarily as polarizers and beam splitters for electromagnetic radiation in the overlapping ranges of long infrared and microwaves. The new manufacturing technology includes refinements and combinations of established techniques for winding grids of electron tubes and ruling optical gratings and incorporates recent developments in electronic control and laser/electronic-based metrology.

The manufacturing equipment and process are illustrated in the figure. A wire grid is wound on one-half of a frame of Invar 36 (or equivalent) low-thermal-expansion alloy machined and ground by optical techniques to a flatness of 2 μm. The frame is mounted with steel bearing rods at opposite ends and aligned on an aluminum platen so that the wires will wrap in the proper direction. The platen is mounted in a modified milling machine, which turns the platen at 4 r/min to wrap the wire. The wire (typically gold-coated tungsten 20 μm in diameter) is released onto the rotating frame through a constant-tension active despooling system and a glass wire guide.

The despooler and guide are mounted on a motor-driven cathetometer that can travel as much as 25 cm with minimal twist. The position of the cathetometer is measured by a laser ranging interferometer operating in conjuction with a desktop computer. During the portion of each revolution of the platen when the frame faces away from the wire guide, the computer commands the cathetometer to translate the despooler and wire guide one grid interval (typically 53 μm) along the edge of the frame.

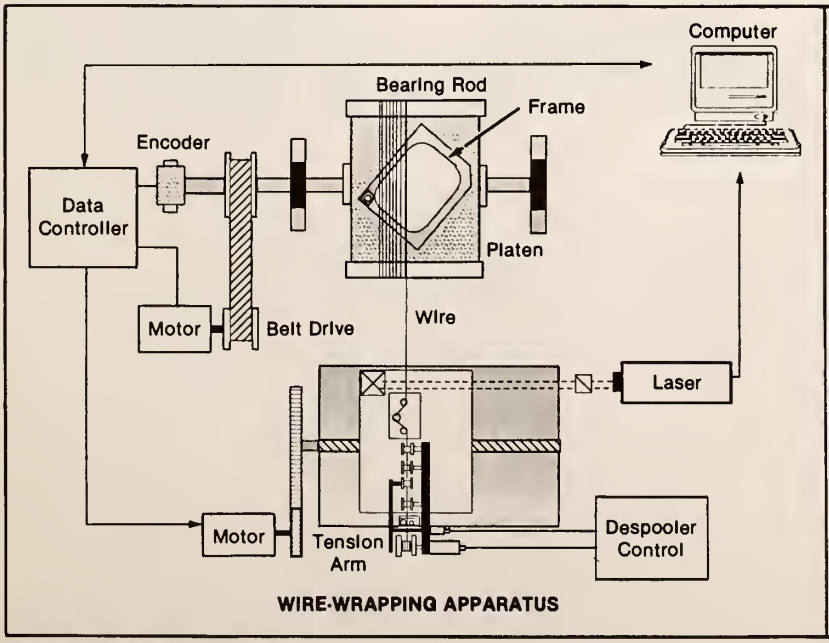
When the cathetometer has stepped along the entire length of the frame and the entire aperture is wrapped with the wire grid, epoxy is dropped into a groove in the frame to affix the wires. When this epoxy has cured, more epoxy is applied to the portion of the frame outside the groove, and the other half of the frame is clamped on, aligned with dowels. After curing of the epoxy, the portion of the wire protruding from the frame is cut away, and the completed frame and grid are removed from the platen.

The flatness of the grid and the spacing of the wires are measured with equipment similar to that used to wrap the wires. (Some of the same equipment can be used for wrapping and measurement.) For the measurement of flatness, the grid is mounted on a two-axis translation stage on which the y-axis is monitored by the laser ranging interferometer with a straightness-measuring adapter. The grid is translated along the x-axis in front of a fixed microscope with a depth of focus of ~1 μm. At each inspection point, the y-axis translation is adjusted for best focus, and the interferometer reading is sent to the computer. The deviation of the resulting computer-generated plot of y vs. x from a straight line gives a measure of the deviation from flatness.

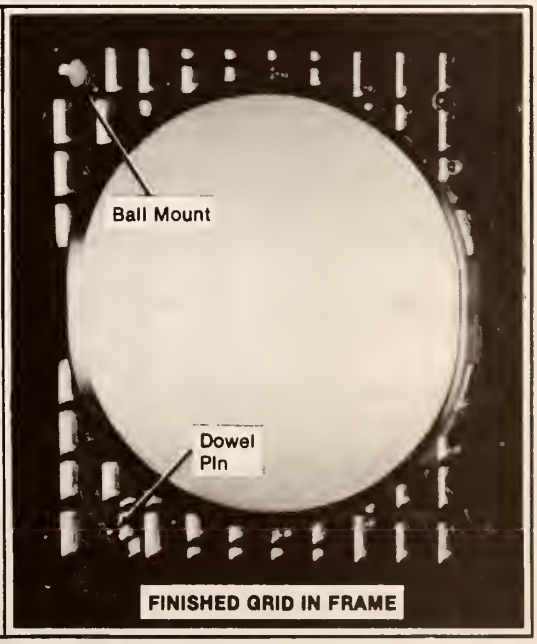
For the measurement of spacing, the x-axis is monitored by the laser ranging interferometer, and the microscope images the wires on a photodetector, the output of which is sampled by an analog-to-digital converter and transmitted to the computer. The computer locates the edges of the wires by looking for signals above and below a threshold value and uses the locations of the edges to compute the distances between the wires.

*This work was done by Thomas J. Magner, Richard D. Barney, William L. Eichhorn, and Henry P. Sampler of* **Goddard Space Flight Center.**

*GSC-13117/TN*




WIRE-WRAPPING APPARATUS




FINISHED GRID IN FRAME

**Wire Is Wrapped on a Frame Half** that is translated under automatic control to achieve the desired space between turns. The frame halves are put together, and the excess wire is cut away, leaving the finished grid mounted in the frame.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

## New Methods for Generating Gear Surfaces

Conjugate surfaces can be generated and analyzed for a variety of useful configurations.

A report presents new methods for generating spur, helical, and spiral-bevel gears. These methods provide conjugate gear-tooth surfaces for the meshing of spur gears with crowned pinion-tooth surfaces that have misaligned axes, for the meshing of helical gears with pinion circular-arc teeth as well as gear regular screw involute teeth that have a change in center distance, and for the meshing of spiral-bevel gears, the common surface of which normally performs a parallel motion in the process of meshing. Furthermore, these methods provide the gears with localized bearing contact as well as a reduction in kinematic errors (gear noise) due to the misalignments of gears.

Computer programs for the analysis of tooth contacts have been developed for these gears. These programs make it possible to simulate gear meshing and bearing contact and to investigate the influence of misalignments of gears on kinematic errors. The proposed gear-generation methods can be applied to the spiral-bevel gears by the use of currently available machinery and tools, but new tool shapes will be required for the spur and helical gears.

*This work was done by John J. Coy and Robert F. Handschuh of* **Lewis Research Center**, *F. L. Litvin and W.-J. Tsung of the University of Illinois at Chicago, and C.-B. P. Tsay of National Chiao Tun University. Further information may be found in NASA TM-88862* Price Code A03 *"New Generation Methods for Spur, Helical, and Spiral-Bevel Gears."*

*Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-14570/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## Better Sheet Metal Products with Less Waste

Manufacturers of goods fabricated from sheet metal may be able to cut down on waste and scrap thanks to an ultrasonic test developed by NIST working with universities and industry groups. Project collaborators are NIST, Iowa State University, Colorado School of Mines, and the Advanced Steel Processing and Products Research Center at the Colorado School of Mines. A major concern of manufacturers of cars, trucks, appliances, metal furniture, cans, and other items formed or stamped from steel and aluminum sheet is the problem of insufficient or variable formability. The new NIST method uses an electromagnetic-acoustic transducer (EMAT) to launch ultrasonic waves into the sheet metal to measure texture and formability. Ultrasonic measurements have shown a high degree of correlation with traditional measures of formability in the specimens of thin steel examined far, and the tests have covered the range of formability characteristics typically found in industrial applications.

FOR ADDITIONAL INFORMATION:

To discuss these efforts further, contact Mr. Van Clark, National Institute of Standards & Technology, 325 Broadway, Division 430, Boulder CO 80303; (303) 497-3159

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

# Plug Would Collimate X Rays

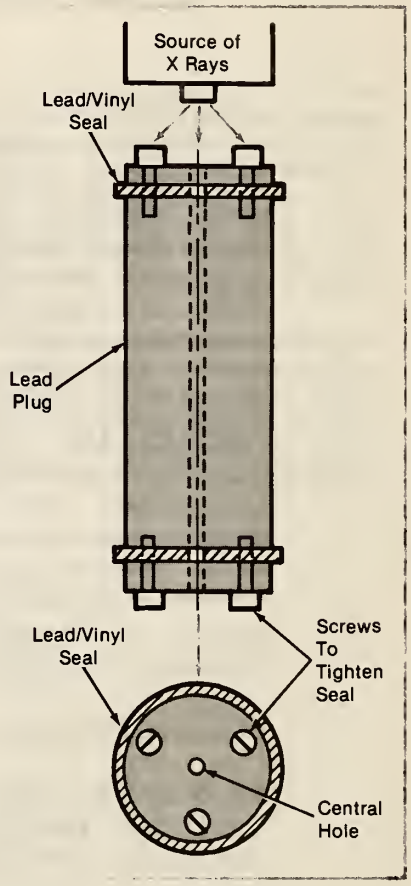
A simple device would create a narrow, well-defined beam for radiographic measurements of thickness.

A proposed cylindrical plug would collimate and align x rays with respect to through holes in parts. The plug would help in the determination of wall thickness by radiography.

The plug would contain an axial hole through which the x rays pass from a source through the part (see figure). Composed of lead with lead/vinyl seals at both ends, the plug would be inserted in the through hole. Rays that deviate from the axial direction of the hole 0.050 in. (1.27 mm) in diameter, would be stopped by the lead. The small diameter of the hole would constrict the x-ray beam. Thus, the x rays emerging from the hole would form a sharply defined beam of round cross section, even if the x-ray source is slightly misaligned.

*This work was done by Jeffrey E. Anders and James F. Adams of Rockwell International Corp. for* **Marshall Space Flight Center.** *No further documentation is available.*
*MFS-29343/TN*

**Lead Would Absorb X Rays** that do not pass axially through the central hole. Lead/vinyl seals would prevent off-axis rays from passing along the periphery of the plug.




FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

# Three-Dimensional Coaxial Weld Monitoring

Parallax would be incorporated into the optical system.

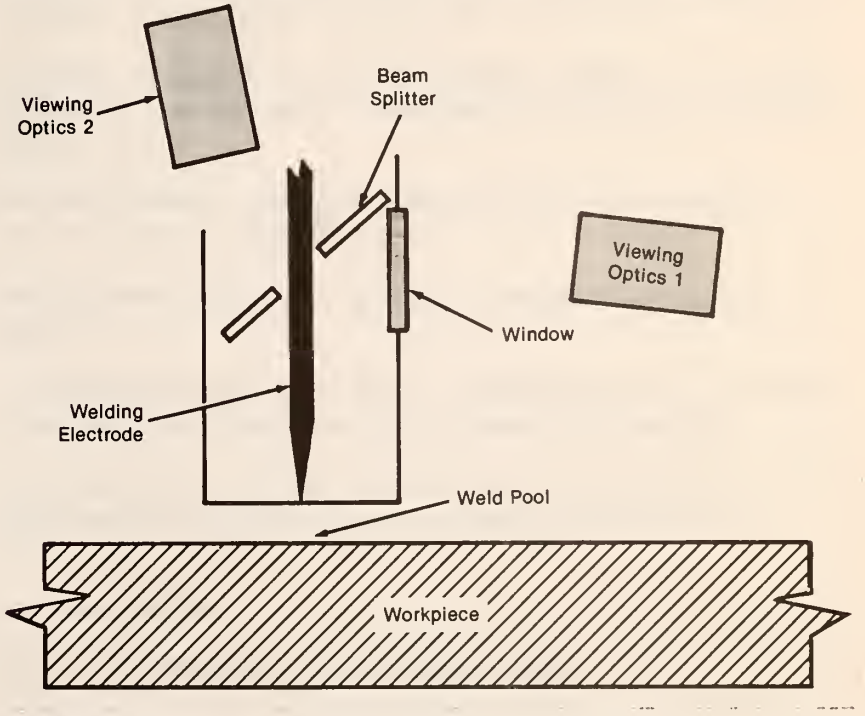
A proposed optical system for a coaxial-viewing welding torch would enable the perception or measurement of depth — that is, of position along the axis of the torch. At present, such optical systems give only two-dimensional views of the welding areas: operators must rely on shadows or changes in focus to infer differences in depth.

In the proposed system, light from the welding area would be passed through a beam splitter into two optical trains to form two images, each being the view along a line that makes a small angle with the axis of the torch (see figure). The two lines of sight would intersect at the weld pool. The parallax between the two views would provide the sensation of depth over the entire field of view.

Information on depth could be used to evaluate the height of the surface of the seam (to detect mismatches, burrs, and the heights of flanged joints), the convexity or concavity of the weld bead (which relates to the penetration of the weld and the rate of deposition of filler metal), and oscillations of the weld pool (which relate to penetration). The information on depth is also useful for determining the angle of entry of the filler wire with respect to the surface of the workpiece and the distance of the torch from the workpiece. The two images might be processed electronically to extract and/or interpret the data on depth.

*This work was done by Stephen S. Gordon of Rockwell International Corp. for* **Marshall Space Flight Center**.

*MFS-29373/TN*




The **Parallax Between Two Sets of Viewing Optics** would provide information on depth in the field of view.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# Materials


0581 Grain Coarsening Associated with Thermal Fatigue in Solder Contacts

0583 New Material Aimed at Measuring Workplace Dust

0584 Titanium Oxide-Dispersion Alloys Prepared by Rapid Solidification

0585 Toughened Ceramics Shown to Exhibit Sensitivity to Fatigue

0587 Acetylene-Terminated Aspartimides and Derived Resins—New polymers and derived blends exhibit improved processability and properties. (Licensing Opportunity)

0588 Canning of Powdered Metal for Hot Isostatic Pressing—The quality of the specimen is enhanced by an improved canning process. (Licensing Opportunity)

0589 Functional Microspheres—Tiny beads develop from an aqueous solution. (Licensing Opportunity)

0590 Making Single Crystals of $B_4C$—Crystals precipitate from solution in copper.

0591 Improving Thermoelectric Properties of (Si/Ge)/GaP Alloys—Annealing in steps increases the figure of merit. (Licensing Opportunity)

0592 Ultra-High-Molecular-Weight Silphenylene/Siloxane Elastomers—These elastomers have enhanced thermal and mechanical properties.

*Testing & Instrumentation*

0593 Conductivity Measurements on Insulating Foams

*Other Items of Interest*

0611 STM Images Expose Unexpected Atomic Structures of Ultrathin Films

## Technology Application

*Lawrence Berkeley Laboratory*

# Grain Coarsening Associated with Thermal Fatigue in Solder Contacts

Thermal fatigue of soldered electrical contacts can be caused by the differential thermal expansion of the materials joined by the solder. As the device containing the contact is repeatedly turned on and off, this fatigue can result in breakage of the contact. Solder failure, therefore is a major problem confronting the microelectronics industry. The solution to the problem, and the resulting achievement of greater device reliability requires both the development of rapid tests to predict contact life and also the design of solders with improved resistance to thermal fatigue. Both require the development of a fundamental understanding of the mechanisms that lead to solder fatigue.

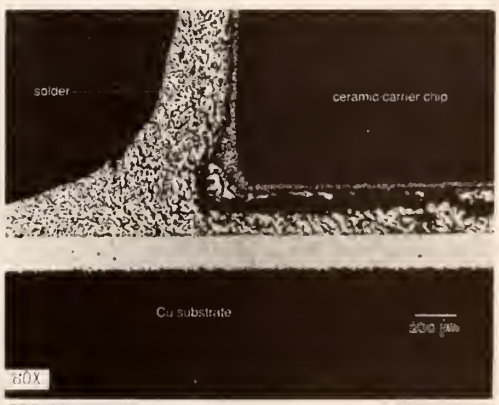
CAM researchers under the direction of J.W. Morris, Jr. have recently shown that thermal fatigue failure of typical Pb-Sn solder contacts is due to strain-induced grain growth in the solder.

The work involved the design and fabrication of a new test specimen, a "club sandwich" of Cu/solder/Cu-coated aluminum/solder/Cu that permits controlled experimental thermal fatigue of the eutectic solder in shear. Microscopic analyses of Pb-Sn solders subjected to this treatment have revealed that the mechanical shear is localized in bands, and that the temperature cycling results in rapid growth of the solder grains within the bands. This grain growth further concentrates the strain, and leads to rapid failure along

a)

XBB 860-10351

b)




CBB 881-14

a) Thermal fatigue in a test specimen of 60Sn-40Pb solder on copper, showing grain growth in a shear band. The light constituent is Sn, the darker phase is Pb, and the dark band along the bottom is the copper. Note the coarsened structure in the band parallel to the interface between the copper and the solder. The fatigue crack, which is particularly noticeable at the right, propagates through this coarsened band.

b) Thermal fatigue in a simulated electrical contact tested at Texas Instruments (by M. Wolverton) under simulated operating conditions. 60Sn-40Pb solder joins a coated ceramic chip carrier to a copper substrate. The solder has coarsened in a band between the carrier and the substrate and has separated in fatigue.

the grain boundaries. The proposed mechanism has been confirmed independently by analyses of solder failures performed by collaborators at Texas Instruments, Inc. Continuing work involves application of these results to the design of more probative tests and more fatigue-resistant solders.

*For Additional Information:*

Office of Research and Technology Application
50A 4112
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Telephone (415) 486-6502

Refer to CAM Volume 2, Number 1/TN

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## New Material Aimed at Measuring Workplace Dust

The various crystalline phases of silicon dioxide--which are found in the airborne dusts produced by industries such as glassmaking and mining--are potential health hazards which can cause respiratory problems. For this reason, agencies that regulate workplace environments need reference standards to ensure the performance reliability of the instruments used to monitor industrial dusts. NIST researchers have developed a standard reference material (SRM) consisting of respirable cristobalite powder, a crystalline form of silicon dioxide, which can be used to calibrate the x-ray diffraction instruments used by regulators.

FOR ADDITIONAL INFORMATION: A 5-gram bottle of the material (SRM 1879) sells for $239 and can be ordered from the Office of Standard Reference Materials, NIST, B311 Chemistry Building, Gaithersburg, MD 20899; (301) 975-6776. The SRM was developed as part of a cooperative program with the National Institute of Occupational Safety and Health.

## Titanium Oxide-Dispersion Alloys Prepared by Rapid Solidification

Oxide-dispersion-strengthening can be produced in titanium alloys by alloy reactive metal additions such as europium (Er), maintaining these additions in supersaturated solid solution by rapid solidification processing then annealing at lower temperatures to form dispersions of fine incoherent oxide particles. Other additions, such as boron, can lead to the formation of whisker-like reinforcing particles. In some cases, such phases are produced during the rapid solidification process; subsequent annealing is not required. Studies of alloys of this type are under way at McDonnel Douglas as part of an Air Force Office of Scientific Research contract.

Dispersions are being produced in three titanium alloy bases, unalloyed titanium, titanium-16 aluminum (Ti3Al), and titanium-36 aluminim (TiAl by rapid solidification alloying with europium, boron, or carbon. Er and C produce spherical dispersed phases after appropriate processing, while B produces a large aspect ratio whisker-like phase.

Powders of the alloys in those systems selected for study have been produced using a rotating electrode method in which molten droplets were caught by a rotating copper plate to produce rapidly solidified flakes. Subsequently, the flakes were sealed in quartz capsules under vacuum and annealed for up to 100 hours at temperatures between 1290 F (700 C) and 1650 F (900 C) to form dispersed phases. The annealed flakes were then characterized with respect to microstructure and strength. (Small tensile specimens were machined from the splat-cooled ribbon.) In subsequent studies, the flakes will be consolidated and fabricated into sheet product 0.12 inch (3mm) thick for more detailed evaluation to determine whether such alloys show promise for structural use in hypersonic aircraft.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703)487-4600.
NTIS order number: AD-A190492/NAC
Price code: A03

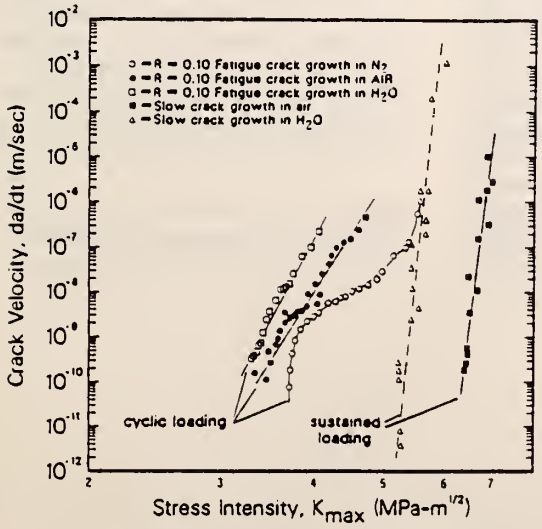
## Technology Application

*Lawrence Berkeley Laboratory*

# Toughened Ceramics Shown to Exhibit Sensitivity to Fatigue

Efforts to capitalize on the high strength and fatigue insensitivity of ceramics for use in structural applications have been hindered by the extreme brittleness of these materials. A significant research effort in many laboratories has therefore been directed towards toughening ceramics, and thus increasing their resistance to fracture. CAM researchers under the direction of R.O. Ritchie report however, that methods now used to achieve this toughening can make the ceramic material dangerously susceptible to fatigue under cyclic loading conditions, significantly reducing their value in applications such as turbine blades which are exposed to vibrations and repeated on-off cycles.

Studies were performed on the toughened ceramic PSZ (partially stabilized zirconia), a material that is specially heat treated to decrease brittleness. They demonstrated, for the first time, the crack-growth rate behavior of fatigue cracks in this ceramic resulting from its cyclic loading under tension-tension conditions. Crack growth velocities were shown to be up to eight orders of magnitude greater than reported rates for the same material under sustained, rather than cyclic loads. Measured threshold stress intensities are also 40% lower under these cyclic conditions. In fact, the sensitivity of crack growth in these materials to environmental conditions and the dependence of the growth rate on stress intensity are analogous to that seen in fatigue of metals. Continuing research at CAM is focused on understanding the mechanism of this increase in fatigue sensitivity and assessing the extent to which it appears in other toughened ceramics.


R = 0.10 Fatigue crack growth in N2
R = 0.10 Fatigue crack growth in AIR
R = 0.10 Fatigue crack growth in H2O
Slow crack growth in air
Slow crack growth in H2O
cyclic loading
sustained loading
Crack Velocity, da/dt (m/sec)
Stress Intensity, Kmax (MPa-m1/2)

**Subcritical crack growth behavior in the toughened ceramic, partially stabilized zirconia showing a comparison of cyclic crack velocities (fatigue), from the present study with sustained-load crack velocities (environmentally assisted fracture) from data of Becher, for nitrogen, 55% relative humidity air, and distilled water. Fatigue-induced crack growth is much faster than even environmentally assisted fracture under sustained loading conditions, although it too is increased in the presence of moisture. This marked sensitivity to fatigue threatens the use of ceramics in cyclic load applications such as turbine blades.**

Mechanical Behavior Project, R. O. Ritchie Project Leader, (415) 486-5798; R.H. Dauskardt, (415) 486-5544

*For Additional Information:*

Office of Research and Technology Application
50A 4112
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Telephone (415) 486-6502

Refer to CAM Volume 2, Number 1/TN

NASA Tech Brief
National Aeronautics and Space Administration
*Langley Research Center, Hampton, Virginia*

**Licensing Opportunity**

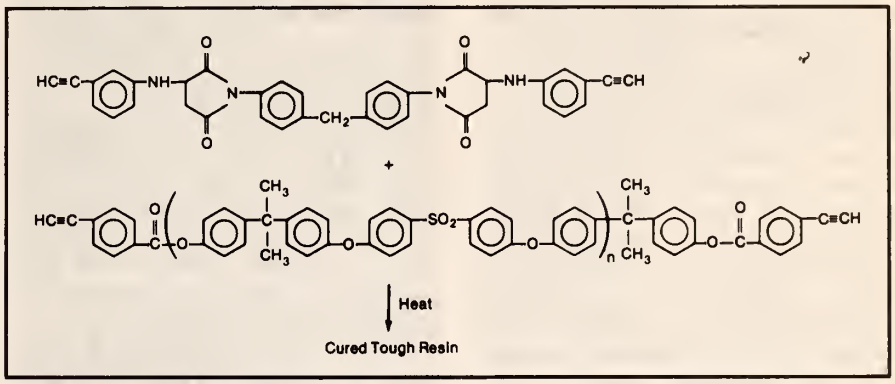
# Acetylene-Terminated Aspartimides and Derived Resins

New polymers and derived blends exhibit improved processability and properties.

Structural resins with favorable combinations of such properties as long-term environmental durability over moderate temperature ranges, tolerance to damage, and resistance to solvents are required for use in hot areas on advanced and commercial aircraft. The new toughened epoxies exhibit excellent properties, but the use temperatures are limited. Bismaleimide resins are some of the base materials being formulated to develop materials that have moderate use temperatures. Accordingly, work has been conducted on the use of the acetylenic (ethynyl) group to cross-link and extend the chains of oligomers and polymers to obtain materials that can perform at higher temperatures. This work has been extended to include acetylene-terminated aspartimides (ATA's).

Novel ATA's were prepared from the reaction of 3-aminophenylacetylene with aromatic bismaleimides and also from the reaction of N-(3-ethynylphenyl)maleimide with aromatic diamines. These ATA's exhibited lower melt temperatures (better processability), higher fracture toughness (better resistance to impact), and better adhesive properties than those of comparable bismaleimides. Novel blends of these ATA's with acetylene-terminated polyarylene ethers were prepared and evaluated as moldings, adhesives, and composite matrices. These cured materials exhibited good fracture toughness, resistance to solvents, and adhesive and composite properties.

For example, the ATA from the reaction of 3-aminophenylacetylene and N,N'-bismaleimido-4,4'-diphenylmethane was blended with an equal weight of an acetylene-terminated sulfone oligomer (see figure). The resulting blend was then molded and cured. A fracture-toughness ($K_{Ic}$, critical stress intensity factor) value of approximately 1,400 psi • in.$^{1/2}$ (1.5 MPa • m$^{1/2}$) was obtained from a specimen molded at a temperature of 230 to 250 °C and a pressure of about 60 psi (0.4 MPa) for 0.5 h. This specimen was not affected by methylene chloride or other solvents. Titanium-to-titanium specimens of the blend provided average tensile shear strengths of 3,600 psi (25 MPa) at 25 °C, 3,200 psi (22 MPa) at 177 °C, 3,000 psi (21 MPa) at 177 °C after 1,000 hours, and 2,600 psi (18 MPa) at 203 °C. The tested specimens exhibited predominantly cohesive failure. The flash from one specimen exhibited a glass-transition temperature of 194 °C.




A **Blend** of an acetylene-terminated aspartimide and an acetylene-terminated sulfone oligomer is heated to produce a cured tough resin.

A prepreg of carbon/graphite fabric was solution-coated with the blend and used to fabricate a final composite with a resin content of approximately 41 percent. The resulting composite at 25 °C exhibited flexural strength, flexural modulus, and short-beam shear strength of 93,500 psi (645 MPa), 7,575,000 psi (52.2 GPa), and 8,600 psi (59 MPa), respectively. At 177 °C, the respective values were 87,800 psi (605 MPa), 6,266,000 psi (43.2 GPa), and 7,200 psi (50 MPa).

*This work was done by Paul M. Hergenrother of* **Langley Research Center**, *John W. Connell of Virginia Commonwealth University, and Stephen J. Havens of PRC Kentron, Inc.*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center*
*Refer to LAR-13730/TN*

**Langley Research Ctr.**
***Technology Utilization Officer: John Samos***
**Mail Stop 139A**
**Hampton, VA 23665**
**(804) 865-3281**
***Patent Counsel:***
***George F. Helfrich***
**Mail Code 279**
**Hampton, VA 23665**
**(804) 865-3725**

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*Lewis Research Center, Cleveland, Ohio*

**Licensing Opportunity**

# Canning of Powdered Metal for Hot Isostatic Pressing

The quality of the specimen is enhanced by an improved canning process.

An improved method has been developed for canning specimens for hot isostatic pressing. The specimen is placed inside a refractory-metal ring, which is then sandwiched between two refractory-metal face sheets. This assembly is placed inside a die, which is then positioned in a vacuum hot press. The specimen is heated to a set temperature at a prescribed vacuum to burn off all of the binder in the specimen.

After burning off of the binder, the temperature of the specimen is raised to a higher set temperature. A prescribed pressing load is then applied to the specimen to deform the refractory-metal ring, to bring about a solid-state-diffusion weld between the ring and face sheets, and to densify partially the composite specimen. The size and shape of the specimen are now locked in place, and a perfectly-fitted hot-isostatic-pressing can, sealed at high temperature and high vacuum, has now been formed. The specimen can now be densified completely by hot isostatic pressing.

This procedure offers several advantages over the prior art. The powder-metallurgy composite is totally purged of the binder sealed in the can in a single operation. This procedure prevents outgassing during hot isostatic pressing, which outgassing could cause incomplete densification, interstitial contamination, and embrittlement of the specimen. The perfectly fitting can maintains the size, shape, and uniformity of the specimen and, thereby, prevents warpage of the specimen caused by uneven stresses. Finally, because it is not necessary to electron-beam weld the can, the material in the weld region does not recrystallize, and there is little possibility of cracking.

*This work was done by John J. Juhas of* **Lewis Research Center**. *No further documentation is available.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center Refer to LEW-14719/TN*

**Lewis Research Center**
*Technology Utilization Officer: Daniel G. Soltis*
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5567
*Patent Counsel:*
*Gene E. Shook*
Mail Code 301-6
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Functional Microspheres

Tiny beads develop from an aqueous solution.

A new process forms beads of polyglutaraldehyde directly from a solution. Thus far, beads ("microspheres") of 0.5-to-1.0-micron diameter with fluorescent or magnetic properties have been made. They are useful in biology, clinical chemistry, and biochemistry since they readily attach to red blood cells when combined with suitable antibodies. The fluorescent or magnetic properties allow such marked cells to be traced and identified.

Previously, glutaraldehyde was polymerized in an aqueous solution. In the new process, a surfactant is added to the aqueous solution, and microspheres are formed. The diameters are uniform and controllable, depending on the glutaraldehyde concentration, the emulsifier concentration, and the pH (see figure).

In this process, a solution of 5 percent glutaraldehyde and 1 percent selected surfactant is polymerized in a mechanical shaker for several hours at pH 11.0 and room temperature. The beads thus formed are washed and collected.

To make fluorescent microspheres, 1 mg of fluorescein isothiocyanate is reacted with ethylene diamine. The product is added to the solution in the shaker. For magnetic microspheres, 2 percent ferrofluidic solution is added to the aqueous solution in the shaker. The magnetic beads are separated from the other reaction products by a magnet.

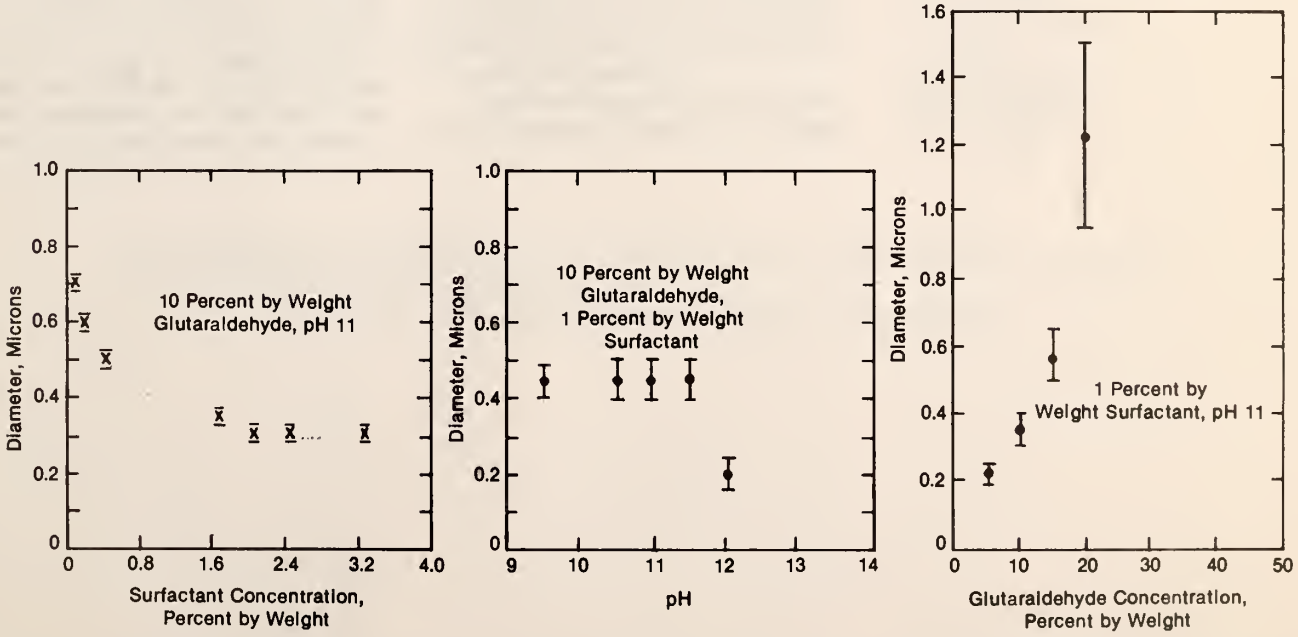
*This work was done by Alan Rembaum and Shlomo Margel of Caltech for* **NASA's Jet Propulsion Laboratory**.

*Title to this invention, covered by U.S. Patent No. 4,267,235, has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)]. Inquiries concerning licenses for its commercial development should be addressed to*

*Edward Ansell*
*Director of Patents and Licensing*
*Mail Stop 301-6*
*California Institute of Technology*
*1207 East California Boulevard*
*Pasadena, CA 91125*
*Refer to NPO-14687/TN*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel:*
*Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734

*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240


Diameter, Microns
10 Percent by Weight Glutaraldehyde, pH 11
Surfactant Concentration, Percent by Weight
10 Percent by Weight Glutaraldehyde, 1 Percent by Weight Surfactant
pH
1 Percent by Weight Surfactant, pH 11
Glutaraldehyde Concentration, Percent by Weight

**The Size of Microspheres Is Controlled** by varying the concentration of aldehyde or surfactant or by altering the pH. The microsphere diameter decreases as the surfactant concentration is increased (left), decreases for more basic solutions (center), and increases as the aldehyde concentration is increased (right).

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and
Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

# Making Single Crystals of $B_4C$

Crystals precipitate from solution in copper.

Well-defined single crystals of boron carbide ($B_4C$) have been grown by slowly cooling melts containing $B_4C$ and copper. Crystals form both on the surface and in the interior of the melt.

In experiments, 36.8 weight percent of prereacted $B_4C$ and 63.2 weight percent of copper were placed in a boron nitride (BN) crucible and heated to about 1,900 °C in an atmosphere of argon and then held at that temperature for about 10 hours. The melt was cooled then at rates in the range of 7 to 10 °C per hour until the entire melt had solidified. After solidification, the material was cooled more rapidly to room temperature. To recover the $B_4C$ crystals, the copper was dissolved away with an aqueous solution of nitric and hydrofluoric acids.

Similar results are expected with other mixture percentages, temperatures, and cooling rates.

*This work was done by Robert S. Feigelson of Stanford University for* **NASA's Jet Propulsion Laboratory**
*NPO-17255/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

Licensing Opportunity

*NASA's Jet Propulsion Laboratory, Pasadena, California*

# Improving Thermoelectric Properties of (Si/Ge)/GaP Alloys

Annealing in steps increases the figure of merit.

A carefully-controlled heat treatment increases the thermoelectric figure of merit of hot-pressed GaP-doped Si/Ge alloy. Si/Ge alloys have been used in thermoelectric devices for more tnan a decade, during which experimental and theoretical work has continued with a view toward understanding and improving these materials.

The thermoelectric figure of merit, $Z$, is given by

$$Z = S^2/\rho\Lambda$$

where $S$ = the Seebeck coefficient, $\rho$ = the electrical resistivity, and $\Lambda$ = the thermal conductivity of the material being characterized. Prior research had shown that at grain sizes of less than 5 $\mu$m, the lattice thermal conductivities of heavily-doped Si/Ge alloys at a temperature of 1,000 K are reduced to about 35 percent below that of single-crystal Si/Ge. However, experiments with GaP-doped, fine-grain, n-type Si/Ge alloys also showed a decrease in $S^2/\rho$, with the result that there was no net increase in $Z$.

In the new heat treatment, GaP-doped Si/Ge is annealed at steps of increasing temperature: 1,200, 1,225, 1,235, and 1,275 °C. In three specimens tested, $\rho$ decreased, causing $Z$ to increase to values ranging from 1.0 to 1.1 $mK^{-1}$, about 30 percent higher than the previous value. Examination of the specimens by scanning-electron microscopy revealed the formation of a phase rich in Ge and Ga, an SiP phase, and particles of $SiO_2$. These new phases may be associated with the increase in $Z$.

*This work was done by Jan W. Vandersande and Charles Wood of Caltech and Susan Draper of Lewis Research Center for* **NASA's Jet Propulsion Laboratory**. *For further information, Circle 115 on the TSP Request Card.*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17259.*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

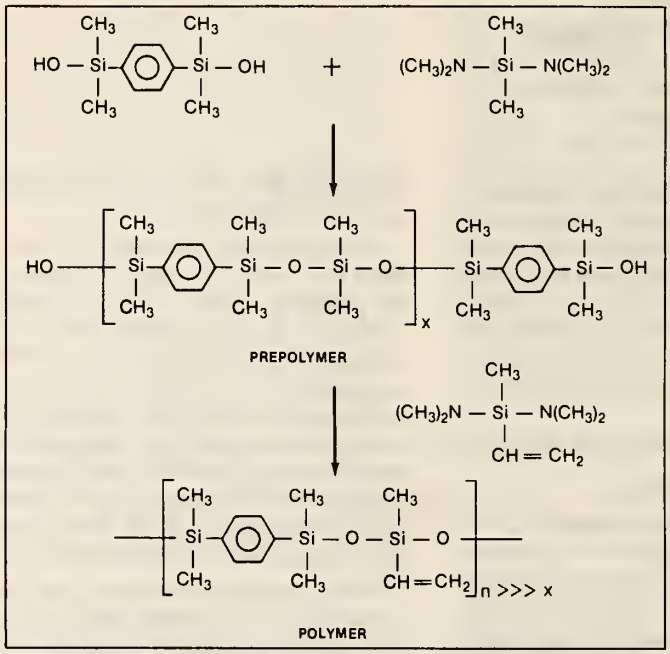
NASA Tech Brief
National Aeronautics and Space Administration
*Marshall Space Flight Center, Alabama*

# Ultra-High-Molecular-Weight Silphenylene/Siloxane Elastomers

These elastomers have enhanced thermal and mechanical properties.

Elastomers capable of performing in extreme thermal/oxidative environments and having molecular weights above $10^6$ have been prepared and analyzed in laboratory experiments. Made of methylvinylsilphenylene-siloxane terpolymers, these new materials are amenable to conventional silicone-processing technology. Compared to similarly formulated commercial methylvinyl silicones, the vulcanized elastomers exhibit enhanced thermal/oxidative stability and equivalent or superior mechanical properties.

The two-stage polymerization technique involved the reaction sequence shown in the figure. Each experimental synthesis began with the incremental addition of 0.90 to 0.98 molar equivalents of bis(dimethylamino)dimethylsilane over a two-day interval to a solution of 1 molar equivalent of 1,4-bis(hydroxydimethylsilyl)benzene in dry toluene refluxing at 95 to 105 °C and mechanically stirred under nitrogen. After the reaction mixture was refluxed an additional day, it was precipitated dropwise in rapidly stirred methanol, yielding the prepolymer (about 80 percent of the theoretical yield) as a low-viscosity gum. The methanol was decanted and the prepolymer was dried overnight in a vacuum oven at 50 °C.




**Methylvinylsilphenylene-Siloxane Terpolymers** of molecular weights greater than $10^6$ have been prepared by reacting 1,4-bis(hydroxydimethylsilyl)benzene with bis(dimethylamino)dimethylsilane to produce a silanol-terminated prepolymer that is then reacted with bis)dimethylamino)methylvinylsilane.

The prepolymer was then similarly reacted over another two-day interval with increments of bis(dimethylamino)-methyl-vinylsilane in an amount equal to approximately 1.6 times the 7.5-percent molar deficiency of the starting bis(dimethylamino)-dimethylsilane. When the reaction was complete, the hot solution was dripped as before into rapidly stirred methanol, the methanol was decanted, and the product, a rubbery gum, was dried in a vacuum oven at 50 °C for two days. A typical yield of polymer is 95 percent, based on the amount of prepolymer used.

Finally, rubber samples were formulated of 25.0 g polymer, 1.25 g Santocel (or equivalent) fumed silica filler, 2.50 g Super Floss (or equivalent) fumed silica filler and either 0.20 g of 2,5-dimethyl-2,5-di(t-butylperoxy)hexane or 0.44 g dicumyl peroxide. The ingredients were milled for 15 minutes on a microrubber mill, left overnight, vulcanized under pressure for 20 minutes in a preheated mold at 338 °F (170 °C), then removed from the mold and cured for 16 hours in an oven at 450 °F (232 °C).

In measurements of the ultimate strength, Young's modulus, percent elongation at failure, and tear strength, the experimental elastomers proved superior to the commercial methylvinyl silicones. The prepolymers of lowest molecular weight yielded the strongest elastomers. Stronger elastomers were produced with dicumyl peroxide than with 2,5-dimethyl-2,5-di(t-butylperoxy)hexane.

Gradient and isothermal thermogravimetric analyses performed in both air and nitrogen demonstrated superior thermal/oxidation stability for the experimental elastomers. However, despite its inherent thermal stability, the experimental elastomer (like the commercial elastomer) exhibited extensive degradation of its mechanical properties after being exposed to 550 °F (288 °C) for 16 hours.

*This work was done by N. H. Hundley and W. J. Patterson of* **Marshall Space Flight Center.** *Further information may be found in NASA Technical Paper 2476 [N85-26990/NSP], "Formulation/Cure Technology for Ultra-High-Molecular-Weight Silphenylene-Siloxane Polymers" A02 .. A paper copy may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.*

*MFS-27120/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## Conductivity Measurements on Insulating Foams

Polymethacrylimide (PMA) and polyurethane foams are used as thermal insulation in many applications, including the vacuum of high altitudes and outer space. In work done for NASA's Langley Research Center, NIST measured the thermal conductivity of several foams in a guarded-not-plate apparatus at temperatures of about 100 to 300 kelvin (-280 to 80°F). Most of the tests were done in dry nitrogen gas at slightly above ambient pressure, with one test repeated at 0.67 Pa (six millionths of an atmosphere). The specimens included neat PMA foams, a PMA foam sandwiched between layers of glass cloth, adhesive, and aluminized polymide film, and polyurethane foam sprayed onto a 2-mm-thick aluminum substrate. The apparent conductivity of the vacuum-tested sample (polyurethane-aluminum) was lower than the same sample tested in gas, probably because the vacuum reduced the heat transfer between the sample and the apparatus' hot plate.

FOR ADDITIONAL INFORMATION: Results of these tests are presented in Thermal Conductivity of Selected Foams and Systems from 100 to 300 K (NBSIR 88-3086), available from the National Technical Information Service, Springfield, VA 22161, for $14.95 prepaid. Order by PB#88-201553/NAC.

# Medicine & Biology

0594 Advances in Diagnostic and Treatment Methods in Carcinoids

0596 Collection of Viruses, Molecularly Cloned Viruses, Viral Antisera, Chlamydiae, and Rickettsiae

0597 Laboratory Culture of Octopus for Biomedical Research

0598 New Evidence on Role of Fatty Blood Fraction in Heart Disease

0600 Referral Center for Animal Models of Human Genetic Disease

*Software*

0602 Indoor Air Quality Model Version 1.0

*Testing & Instrumentation*

0604 Real Time Speech Formant Analyzer and Display

*Other Items of Interest*

0568 Development of a High Volume Surface Sampler for Pesticides in Floor Dust

0606 Engineer's Refractive Effects Prediction Systems (EREPS)

0607 First Images of DNA Helix Obtained

NIH
Research & Technology
U.S. Department of Health and Human Services Public Health Service National Institutes of Health

# Advances in Diagnostic and Treatment Methods in Carcinoids

A new diagnostic imaging technique and an analogue of somatostatin may make the diagnosis and treatment of carcinoid tumors more effective, according to researchers in General Clinical Research Centers at the University of Michigan and Duke University Medical Center.

Carcinoid tumors, which occur most frequently in the gut, can lead to the development of a group of symptoms—flushing, wheezing, diarrhea, and cardiac fibrosis—known as the carcinoid syndrome. This syndrome is associated with secretion of several neuropeptides, such as calcitonin and adrenocorticotropic hormone (ACTH), that regulate various physiologic functions. Carcinoid tumors associated with the carcinoid syndrome also produce serotonin which is metabolized to 5-hydroxyindoleacetic acid (5-HIAA). Measuring levels of serotonin or 5-HIAA is one means of diagnosing and following the disease. The tumors themselves are slow growing and may not be correctly diagnosed until they have metastasized to the liver.

Dr. Jerome Feldman, associate professor of medicine at Duke University and chief of the endocrinology and metabolism section at the Durham, North Carolina, Veterans Administration Medical Center, is researching both the diagnostic and therapeutic potential of the compound metaiodobenzylguanidine (MIBG), which contains the radioactive isotope iodine-131. MIBG has an affinity for neuroendocrine tumors related to both the nervous and endocrine systems. These tumors are derived from embryonic cells that become part of the intestines, thyroid, adrenal medulla, lung, and pancreas.

In Dr. Feldman's study of 80 patients at Duke, MIBG was taken up by the carcinoid and helped locate the tumor, appearing as a "hot" area on scintiscans. Midgut carcinoid tumors (from the ileum and cecum) concentrate the isotope more readily than foregut carcinoid tumors (from stomach, pancreas, and bronchus), he says.

Among patients with carcinoid tumors of midgut origin MIBG was concentrated by carcinoid tumors in liver or lymph glands, although hepatic metastases less than 1 cm in diameter were not visualized.

Dr. Brahm Shapiro, professor of internal medicine in the division of nuclear medicine, department of internal medicine, University of Michigan Medical Center, points out that the liver is the most common site for carcinoid metastases. However, he has been able to obtain positive MIBG scintiscans in only 4 of 10 cases of histologically proved carcinoid tumors with liver metastases.

"MIBG is more sensitive for adrenal gland tumors than for other neuroendocrine tumors such as carcinoids," he says. "However, it may have a role in diagnosis of carcinoids in those whose tumors are not demonstrated on computed tomography or magnetic resonance imaging scans. To determine its exact role in other neuroendocrine tumors, we need to look at it in a wider spectrum of lesions and larger numbers of patients," Dr. Shapiro says.

Dr. Feldman believes that the positive results his groups have obtained result from differences in imaging techniques. Because normal liver concentrates MIBG to some extent, the Duke investigators use a different subtraction scanning technique to better define tumor deposits in the liver.

"MIBG is most useful in finding metastases of carcinoids,

although in one case it identified a primary carcinoid in the pancreas," Dr. Feldman says.

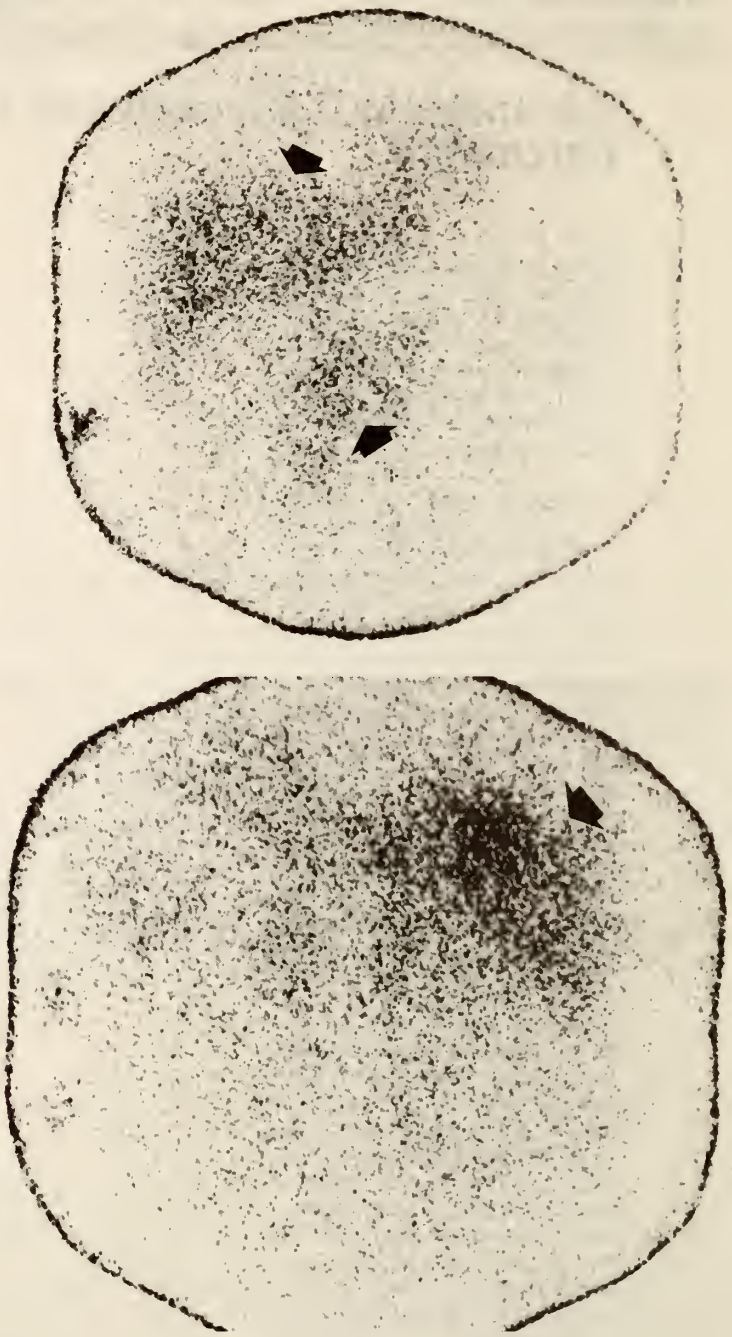
"The affinity of carcinoids for this radioisotope suggests that it may be a way to deliver radiation to the tumor," he notes.

*For Additional Information:*

To locate information or professional contacts on this effort, contact:

Research Resources Information Center
1601 Research Boulevard
Rockville, MD 20850
(301) 984-2870

Refer to Volume XIII, No. 1/TN



Journal of Nuclear Medicine 27:1694, 1986

*Top, an anterior MIBG scan performed 48 hours after a patient with a carcinoid tumor of the pancreas received isotope injection. Upper arrow shows normal MIBG uptake in the anterior region of the liver; lower arrow shows abnormal uptake in the primary carcinoid tumor located in the head of the pancreas. Bottom, a posterior scan performed 48 hours after isotope injection, with arrow showing abnormal MIBG uptake in a metastatic tumor in the posterior region of the liver.*

NIH
Research & Technology
U.S. Department of Health and Human Services Public Health Service National Institutes of Health

*Federal Laboratory Resource*

# Collection of Viruses, Molecularly Cloned Viruses, Viral Antisera, Chlamydiae, and Rickettsiae

*Coprincipal Investigator:*
**Candace W. Collmer, Ph.D.**
Acting Head, Department of Virology
American Type Culture Collection
12301 Parklawn Drive
Rockville, Maryland 20852
(301) 881-2600

*Director:*
**Robert E. Stevenson, Ph.D.**

## Resources Provided

- The virology collection is the largest diversified repository of reference and prototype virus strains in the world, currently including around 2,000 animal viruses, animal viral antisera, chlamydiae, rickettsiae, molecularly cloned viruses, oncogenes and proto-oncogenes; and around 400 plant viruses, plant viral antisera, and molecularly cloned plant viruses. A catalog that includes data and references is available without charge.
- *Basic Objective:* Acquisition, preservation, and authentication of viruses, viral antisera, chlamydiae, rickettsiae, molecularly cloned viruses and oncogenes for distribution to the scientific community. Acquisition and/or development of cloned viral genomes or parts thereof useful as probes in detection or identification of viral diseases. Compilation of viral data for the establishment of a data base that can be queried by scientists.
- *Current Research:* Application of new recombinant and molecular techniques for viral authentication and viral relationship studies. Development of optimum methods for preservation of viruses currently difficult to preserve.

NIH
Research & Technology
Federal Laboratory Resource
U.S. Department of Health and Human Services Public Health Service National Institutes of Health

# Laboratory Culture of Octopus for Biomedical Research

*Principal Investigator:*
**Roger T. Hanlon, Ph.D.**
Marine Biomedical Institute
200 University Boulevard
League Hall H63
University of Texas Medical Branch
Galveston, Texas 77550-2772
(409) 761-2133

## Resources Provided

- *Animals:* The resource is under development. The species in culture are *Octopus digueti, Octopus maya,* and *Octopus bimaculoides.* A limited number of octopuses, including eggs or hatchlings, are available on a selective basis.
- *Other Services:* Information on the transport, maintenance, and culture of octopuses is available. Information may also be obtained on the potential uses of octopuses in research, especially environmental toxicology, comparative psychology, genetics, and physiology.
- *Contact Persons:* Roger T. Hanlon, Ph.D., or John W. Forsythe, M.S., (409) 761-2133.

## Research Emphasis or Application

- *Basic Objectives:* To develop a reliable and reproducible methodology for the large-scale culture of large-egged octopuses, making these well-developed molluscs readily available for biomedical research.
- *Current Research:* Evaluation of each species' tolerance to high-density culture; development of simple, reproducible closed seawater systems; identification and treatment of disease-causing organisms; water quality tolerances; determinations of food preferences and production of artificial food rations; and evaluation of species' suitability for various biomedical applications.

*Lawrence Berkeley Laboratory*

# New Evidence on Role of Fatty Blood Fraction in Heart Disease

New research at the Lawrence Berkeley Laboratory indicates that a fatty-protein compound known as Lp(a) may be much more significant than either total cholesterol or "good" and "bad" lipoproteins (HDSs and LDLs) in predicting the rate at which fatty deposits build up in coronary arteries.

LBL researcher Frank Lindgren of the Research Medicine and Radiation Biophysics Division reported the new findings.

A new, accurate assay technique has been developed for measuring concentrations of Lp(a) in the blood, and for distinguishing subfractions of varying densities.

The study followed 40 patients of Dr. Blankenhorn who had had coronary by-pass surgery in the past, and who were on various regimes of medication to reduce Lp(a) and prevent recurrence of arteriosclerosis. Using the new assay technique, Lindgren and his co-workers measured three different density fractions of Lp(a) as well as the more commonly used indicators-total cholesterol, high-density lipoproteins (HDLs), and low-density lipoproteins (LDLs).

All the patients had angiograms after their original surgery and again after two years, so that the actual degree of arteriosclerosis build-up over a two-year period could be ascertained. The study found that a high level of Lp(a) was the best predictor of new arterial blockage by fat deposits. The highest correlations were with the densest types of Lp(a).

The findings could point the way towards possible new tests that could predict more accurately those at risk for heart attack. At present, however, testing for Lp(a) requires sophisticated laboratory equipment, and would be prohibitively expensive to undertake on a mass scale.

Lp(a), a macromolecule larger than the LDLs, is not a newly discovered compound, but its significance in arteriosclerosis-especially its genetic features-has only recently come to light. Before the development of the new assay technique, the only way to measure Lp(a) in the blood was by means of difficult and complex immunoassay techniques. Such techniques give only a total Lp(a) level, and-because LP(a) may cross-react with other products-do not permit quantitative analysis of the various subfractions of the macromolecule.

The new assay technique is a variation on similar techniques that have been developed at LBL to study HDLs, LDLs, and other blood fractions. The samples are first separated into lighter and heavier components by means of ultracentrifugation, and then further distinguished by a technique known as quantitative gradient gel electrophoresis.

FOR ADDITIONAL INFORMATION: Public Information Department, Lawrence Berkeley Laboratory, Berkeley, CA 94720; Telephone (415)486-5771.

**Federal Laboratory Resource**

# NIH Research & Technology

U.S. Department of Health and Human Services Public Health Service National Institutes of Health

## Referral Center for Animal Models of Human Genetic Disease

*Principal Investigator:*
**Donald F. Patterson, D.V.M., D.Sc.**
Professor of Veterinary Medicine and Human Genetics
School of Veterinary Medicine
University of Pennsylvania
3800 Spruce Street
Philadelphia, Pennsylvania 19105
(215) 898-8880

### Resources Provided

**To Outside Investigators**

• *Consultation and Diagnostic Services:* A primary objective of the referral center is to provide consultation, certain diagnostic services, and preliminary genetic studies to facilitate the discovery and preservation of new and potentially useful animal models of human genetic disease. Emphasis is on models that occur in domestic animals. Priority is given to studies of models that appear to offer the most promising potential for investigating underlying mechanisms and new approaches to therapy. Services available depend on preliminary consultation and evaluation of the potential model by scientists at the referral center. These general classes of genetic disease are emphasized:

—*Hereditary Metabolic Diseases:* Includes inborn errors of amino acid, organic acid, carbohydrate, and glycosaminoglycan metabolism.
Contacts: Dr. Urs Giger, (215) 898-8076; Dr. Mark Haskins, (215) 898-8894.

—*Hereditary Defects in Sexual Development:* Includes male and female pseudohermaphroditism, sex reversal, and true hermaphroditism.
Contacts: Dr. Donald F. Patterson, (215) 898-8880; Dr. Vicki Meyers-Wallen, (215) 898-8880.

—*Hereditary Congenital Malformations:* Includes congenital heart disease and anomalies of other organ systems. Particular emphasis will be given to malformation syndromes that may be due to chromosomal anomalies.
Contacts: Dr. Donald F. Patterson, (215) 898-8880; Dr. Mark Haskins, (215) 898-8894.

—*Hereditary Hematologic Diseases:* Includes inborn errors of erythrocyte metabolism, membrane defects, and leukocyte defects resulting in immune deficiencies.
Contact: Dr. Urs Giger, (215) 898-8830.

—*Hereditary Diseases of the Eye:* Particularly defects of the retina.
Contact: Dr. Gustavo Aguirre, (215) 898-8845.

—If after the initial consultation an affected animal is deemed a potentially new and useful model, these services are available:

—*Clinical Examination:* Usually arrangements for transporting the affected animal to the center are the responsibility of the veterinarian or investigator who made the referral. Physical examinations and routine diagnostic tests are performed. If an animal shows sufficient promise as a disease model, the center pays shipping charges. If the animal is owned by the client and the examination is primarily in the interest of the owner, a reduced fee for clinical services is charged to the owner.

—*Postmortem Examination:* Based on initial consultation, the center provides instructions for fixation. Examinations include gross and microscopic studies of whole organs and tissues. Electron microscopy and special histochemical stains may be used.

—*Metabolic Screening:* This consists of a series of chromatographic and spot tests designed to detect abnormalities in the

types or concentrations of metabolites in body fluids. Urine is usually submitted as the material for initial studies.

—*Hematologic Evaluation:* If the initial evaluation suggests an inherited hematologic defect, erythrocyte and leukocyte function tests are performed, including erythrocyte membrane, hemoglobin, and enzyme screens, as well as leukocyte function studies.

—*Other Biochemical Studies:* Results of histologic studies and/or metabolic screening determine the additional studies required. Such examinations include studies of the concentrations of specific substrates in tissues and fluids and assays of specific enzymes.

—*Cytogenetic Studies:* Currently these studies are confined to the dog and cat and include standard and Giemsa banded karyotyping. These studies are available only on a limited basis and are conducted only when preliminary studies yield sufficient evidence to suspect that a chromosomal anomaly may be present.

—*Pedigree Analysis:* When family data are available or family studies are possible, the center classifies the phenotype of family members and examines pedigree patterns for consistency with various modes of inheritance.

—*Breeding Studies:* The center maintains an animal colony facility that can house a limited number of affected animals and their close relatives for breeding experiments designed to verify whether a defect is heritable and to determine the mode of inheritance. These studies depend on whether affected animals and their relatives can be obtained as donations or purchased.

- *Fees for Diagnostic Services:* There is no charge for initial consultation with veterinarians and investigators. Subsequent studies also are performed without charge if deemed appropriate by investigators at the center. When clinical and postmortem examinations are primarily in the interest of an animal's owner, the owner is charged, but usually at a reduced rate.
- *Animals:* Another objective of the center is to establish a small breeding colony for each promising model. The center does not serve as a source of animals for outside investigators, but makes breeding animals or sperm available to those who wish to start their own breeding colonies once initial characterization is completed.

—Breeding stock or sperm is currently available for these models:

—*Hereditary defects of the conotruncal septum* (tetralogy of Fallot, ventricular septal defect, persistent truncus arteriosus): Keeshond dog.

—*Hereditary patent ductus arteriosus:* Dog

—*Mucopolysaccharidosis VI* (aryl sulphatase B deficiency): Cat.

—*XX sex reversal* (XX male syndrome, XX true hermaphroditism): Dog.

—Phosphofructokinase deficiency (Glycogenosis type VII): Dog.

## Research Emphasis or Application

- *Basic Objectives:* To identify, characterize, evaluate, and disseminate animal models of human genetic disease.
- *Current Research:* Research projects involving established models include developmental studies of hereditary congenital heart disease in the dog (morphogenesis of conotruncal malformations and histogenesis of ductal wall defect in patent ductus arteriosus); studies of the pathogenesis and treatment of the mucopolysaccharidoses (MPS I and MPS VI in the cat; MPS VII in the dog); studies of the genetics and pathogenesis of XX sex reversal and the persistent mullerian duct syndrome in the dog; studies of the pathogenesis of hereditary retinal degenerations in the dog; studies of the pathogenesis of a dominantly inherited defect in collagen fibrillogenesis in the cat; studies of the pathogenesis of alpha mannosidosis in the cat; studies of the underlying biochemical defect in dominantly inherited porphyria in the cat.

Newly discovered models currently under investigation include X-linked variable combined immunodeficiency in the basset hound; an autosomal recessive defect in the intestinal absorption of vitamin $B^{12}$ in the giant schnauzer; lethal acrodermatitis in the bull terrier; photoreceptor dysplasia in the miniature schnauzer; phosphofructokinase deficiency in springer spaniels.

United States
Environmental Protection
Agency

Air and Energy
Engineering Laboratory
Research Triangle Park NC 27711

Software

Research and Development

EPA

# Project Summary

## Indoor Air Quality Model Version 1.0

**The manual describes a microcomputer program written to estimate the impact of various sources on indoor air quality in a multiroom building. The model treats each room as a well-mixed chamber that contains pollutant sources and sinks. The model allows analysis of the impact of interroom air flows, HVAC (heating, ventilating, and air conditioning) systems, and air cleaners on indoor air quality. The model is written for the IBM-PC and compatible family of computers.**

**The model is designed for ease of use and is menu driven. Data entry is handled with a fill-in-the-form interface. Default values for interroom air movement and other input data are provided.**

**The predictions from the model have been compared with predictions from other models and with experimental data. The model predictions are in excellent agreement with both.**

**The model is completely documented, including a brief discussion of the theory on which the model is based. Most of the report is devoted to user instructions and demonstrations of how the model can be used.**

**The model is quite useful and allows rapid analysis of the impact of air pollution sources and mitigation measures on indoor air quality.**

***This Project Summary was developed by EPA's Air and Energy Engineering Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

### Introduction

Indoor air quality is determined by the interactions of sources, sinks, and air movement between rooms and between the building and the outdoors. Sources may be located in rooms, in the HVAC system, or outside the building. Sinks may be located in the same locations. Sinks may also act as sources when the pollutant concentrations drop below a given value.

Air movement in a building consists of:

1. Natural air movement between rooms.
2. Air movement driven by a forces air (HVAC) system.
3. Air movement between the building and the outdoors.

The pollutant concentration in a room is calculated by a mass balance of the various pollutants flows.

Amount in – Amount out + Amount produced – Amount removed = Amount accumulated

The analysis can be extended to multiple rooms by writing a system of equations for each room. The amount of air entering a room from all sources (the HVAC system, outdoors, and other rooms) must equal the amount of air leaving the room.

The type of mixing between the pollutant and the room air must be specified before the mass balance equations can be used in a model. Because mixing is complex, the exact mixing cannot be specified; simplifying assumptions must be made. Plug-flow and well-mixed mixing are two common mixing possibilities.

In the plug-flow mixing model, the pollutant concentration varies from point to point along the air flow path. In the well-mixed model, the pollutant concentration is the same for every point in the room.

The current model uses the well-mixed model. This model was selected because data from the EPA test house showed that pollutant concentrations within a room do not vary significantly with position in the room.

Once the mixing is defined, the various mass balances discussed above can be used to write a set of linear differential equations. These equations can be

## Source Terms

A wide range of source terms are available in the model including random on/off sources (cigarettes), sources that are on for a specified period of time (heaters), steady-state sources (moth crystals), and sources with high initial emission rates followed by low steady-state (floor wax). The IAQ model accommodates all these possibilities in an idealized fashion. Each source in the model is discussed below.

### *Cigarette Smoking*

Cigarette smoking is modeled as a random event with from 1 to n cigarettes smoked per hour. The cigarette is turned on at some random time during the hour. A second cigarette is not allowed on until the first cigarette is smoked. Multiple smokers are accommodated in the model; however, all smokers smoke at the same time.

### *Unvented Kerosene and Gas Heaters*

Unvented kerosene and gas heaters are common sources of indoor air pollution. These heaters are modeled as steady-state on/off heaters. The on and off times are part of the data input to the program. Up to three on/off cycles per day are allowed.

### *Moth Crystal Cakes*

Moth crystal cakes can be an important source of volatile organic compound (VOC) emissions indoors. Moth crystal cakes are long-term steady-state sources. The emissions from moth crystals are a function of the temperature and the surface area of the cakes.

### *Other*

The "other" source is provided as a user defined steady-state source. The source cannot be turned off.

### *Sinks*

It is generally recognized that walls and furnishings can serve as collectors (sinks) of indoor air pollutants. Unfortunately, the data on sinks are limited. The model allows investigation of the behavior of sinks by providing a single sink that is a function of the surface area of the walls in the room. This sink can be a pure sink (i.e., pollutants trapped by the sink are not reemitted) or a reemitting sink.

Small chamber and test house studies are planned to provide fundamental data on sink behavior. The results of these studies will be incorporated into the model as soon as they are available.

## The Air-Handling System

The airflows generated by an air-handling system are generally larger than natural airflows. Thus, when an HVAC system is on, the building's airflows are dominated by the HVAC system. Airflow patterns in a building with the air-handling system on may be significantly different from those in the same building with the air-handling system off. For example, many houses have a single return vent for the air-handling system. When the air-handling system is on, airflow is dominated by the flow to the return vent. When the air-handling system is off, airflow is less directed.

The on/off behavior of the air-handling system is modeled by allowing two different airflow patterns to exist in the building: one pattern is active when the air-handling system is on; and the other, when the air-handling system is off. The model switches between these two patterns depending on the state of the air-handling system. The state of the air-handling system (on or off) is determined by a random number generator that ensures that the air-handling system is on for a specified fraction of each hour. The air-handling system may switch from on to off and back several times in an hour. This random switching appears to provide a qualitative description of actual air-handling system behavior. Experiments are planned to determine how well the model fits actual air handler behavior.

## Hardware Requirements

The model requires an IBM-PC or compatible computer with at least 512 k-bytes of RAM, one floppy drive, and a monochrome or color monitor. The model provides graphics on a computer with a color graphics adapter (CGA) or an enhanced graphics adapter (EGA). Graphics are not provided on a monochrome display adapter.

*The EPA author, **Leslie E. Sparks**, is with the Air and Energy Engineering Research Laboratory, Research Triangle Park, NC 27711..*

*The complete report consists of two parts, entitled, "Indoor Air Quality Model Version 1.0,"*
*Paper Copy (Order No. PB 89-133 615/AS; Cost: $21.95)*
*Diskette (Order No. PB 89-133 607/AS; Cost: $50.00, price of Diskette includes paper copy)*
*The above items will be available only from: (subject to change)*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
*Telephone: 703-487-4650*

*The EPA author can be contacted at:*
*Air and Energy Engineering Laboratory*
*U.S. Environmental Protection Agency*
*Research Triangle Park, NC 27711*

# Real Time Speech Formant Analyzer and Display

One out of 20 Americans suffers some degree of hearing loss, and nearly 300,000 are so deaf that they cannot hear human speech, no matter how strongly amplified. Unable to hear voice sounds, the hearing impaired can be frustrated by hours of practicing speech without knowing whether they are speaking correctly. With the invention of a computerized voice training system, Ames Laboratory scientists are helping the deaf to "see" what they say and thus improve their speech.

The system takes in voice sounds from a microphone , analyzes them and displays them on a television screen. Each sound appears as a wave pattern. A model pattern for the correct pronunciation can then be displayed against the attempted sound and a student can practice generating patterns similar to the model. The four basic elements of sound--pitch, tone, intensity and duration--are reflected in the patterns. Students can also practice with patterns they produce themselves.

The system offers many advantages in speech therapy. Students can work at their own pace and monitor their own progress, with or without supervision. Performance is evaluated almost instantly, with built-in scoring software. The instructor can also adjust the scoring to prevent discouragement and build confidence. The speech analyzer also provides a new way to teach sounds that are generated deep inside the mouth and are thus difficult to imitate.

This invention is the winner of a 1984 IR-100 Award.

---

**Literature:** Fitzgerald, Michele, "Volta Software Review," *The Volta Review*, 89 (3), April 1987, p. 171-173.

**Patent /License Status:** U.S. Patent No. 4,641,343. Micro Video of Ann Arbor, Michigan has been granted an exclusive license and is manufacturing, marketing, and developing the system.

**Potential Applications/Spinoffs:** Program modules for foreign language labs, at-home training, hospital rehabilitation, and speech clinics.

**For More Information on this Technology:** Contact Daniel E. Williams, Office of Research and Technology Application, Ames Laboratory, 119 Office and Laboratory, Iowa State University, Ames, Iowa 50011 (515)294-2635.

---

AL 88-05

# Natural Resources Technology & Engineering

0605 Samara Probe for Remote Imaging—This conceptual device would scan automatically, without costly aiming or stabilizing devices. (Licensing Opportunity)

*Software*

0606 Engineer's Refractive Effects Prediction Systems (EREPS)

*Other Items of Interest*

0515 Floating Raceways Developed for Salmon Culture

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Samara Probe for Remote Imaging

This conceptual device would scan automatically, without costly aiming or stabilizing devices.

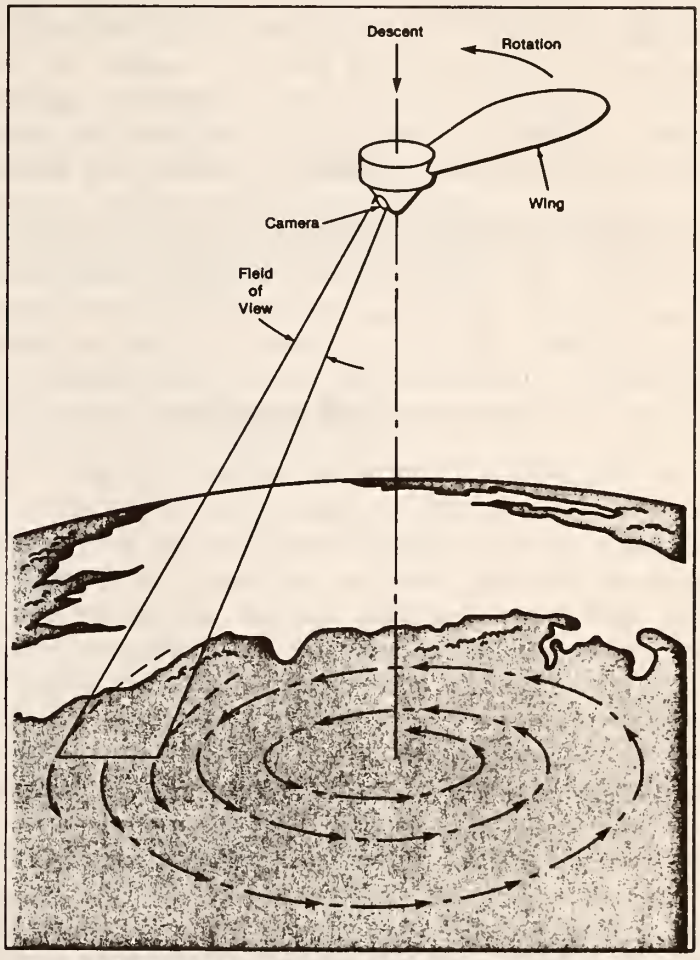
A proposed imaging probe would descend through the atmosphere of a planet, obtaining images of the ground surface as it travels. The probe could be released from an aircraft over the Earth or from a spacecraft over another planet.

The probe would have a body and a single wing shaped much like a samara — a winged seed like those of maple trees. It would therefore rotate as it descends, providing a panoramic view of the terrain below (see figure). The probe would radio the image obtained by its video camera to the aircraft or spacecraft overhead.

The probe would be simple and inexpensive. It would contain no moving parts and would need no fuel or power for scanning, because its panning motion would be imparted by aerodynamic forces. Several such probes could provide comprehensive, detailed maps of a region without the complexity of horizontal travel on the surface or through the atmosphere.

The wing would be propeller shaped and would be pitched for the desired rate of descent and rotation. The camera (or radar) would be mounted on the lower part of the probe at a fixed angle with respect to the spin axis. The field of view of the camera lens would determine the required amount of overlap of the image on successive rotations; a wider angle would cause more — and earlier — overlap. The resolution of the image would increase gradually as the probe approaches the surface.

The upper surface of the wing could carry solar-cell panels, if necessary, to supply power to the camera and transmitter. The transmitting antenna would be embedded in the probe. The wing could also carry a Sun sensor to furnish data on orientation and spin to aid in subsequent processing of the images. (Image processing would be required to remove effects due to nutation and wind drift.) A second wing, like that on certain seeds, could be added to slow the descent and reduce nutation.




**The Autorotating Probe Would Give Images** of areas along a spiral path. The probes should be inexpensive enough that many such units could be deployed to cover a large area.

*This work was done by James D. Burke of Caltech for* **NASA's Jet Propulsion Laboratory**.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL Refer to NPO-17390.*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734

*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

## Engineer's Refractive Effects Prediction Systems (EREPS)

The system is a collection of individual programs that have been designed to assist an engineer in properly assessing electromagnetic propagation effects of the lower atmosphere on proposed radar, electronic warfare, or communication systems. Revision 1.00 consists of three individual IBM-PC programs named PROPR, SDS, and RAYS. PROPR generates a plot of path loss, propagation factor, or radar signal-to-noise ratio versus range for a variety of environmental conditions from which signal levels relative to a specified threshld or maximum range can be determined. SDS displays an annual historical summary of evaporation duct, surface-based duct, and other meteorological parameters for many 10- by 10-deg squares of the earth's surface.SDS is the primary source of environmental inputs to PROPR. RAYS is a raytrace program that shows altitude-vs.-range trajectories of a series of rays for any user-supplied refractive-index profile, and includes an option to display altitude error relative to a standard atmosphere.

EREPS contains many similarities to the Integratged Refractive Effects Prediction System (IREPS) described by Patterson et al. [1] that has been used by the United States Navy and other organizations since 1978 for operational propagation assessment. However, there are fundamental differences between EREPS and IREPS. IREPS was developed to provide operational assessment to a wide variety of existing equipments by means of in situ measured environmental data. Much of the program deals with maintaining libraries of existing systems parameters and entering divergent sources of environmental data. IREPS is not well suited to comparing the performance of two sensors that may differ by only one parameter, such as radar pulse length, or to showing relative performance for a given system as one environmental parameter, such as wind speed or evaporation duct height, changes value. EREPS has been specifically designed for these comparative studies using interactive graphics displays. Also, EREPS is much better suited than IREPS to long-term statistical performance assessment for a specified area. Finally, the EREPS models have been improved to give better results for low-altitude applications.

The EREPS programs were developed using Microsoft QuickBASIC Version 3.0 and are distributed as compiled executable files.The basic source code is available by special request. Minimum system requirements are one 360-Kbyte floppy drive, 640 Kbytes of memory, and either a CGA or EGA graphics adapter.

FOR ADDITIONAL INFORMATION: Problems or inquiries should be addressed to Dr. Herb Hitney, Code 543, Naval Ocean Systems Center, San Diego CA 92152-5000; (619)553-1428.

# Physical Sciences

0607 First Images of DNA Helix Obtained

0608 New, Accurate Measurement Made for R-134a

0609 Surface Properties of Polymers Predicted by Molecular Modeling

*Testing & Instrumentation*

0611 STM Images Expose Unexpected Atomic Structures of Ultrathin Films

0613 Photovoltaic Hydrogen Sensor—The quantum efficiency of a cell decreased in the presence of hydrogen.

*Other Items of Interest*

0589 Functional Microspheres—Tiny beads develop from an aqueous solution. (Licensing Opportunity)

*Lawrence Berkeley Laboratory*

# First Images of DNA Helix Obtained

The first direct images of individual lengths of native (unaltered) DNA that show the double helix have been obtained by a team of scientists from the Lawrence Livermore National Laboratory (LLNL) and the Lawrence Berkeley Laboratory (LBL).

The three dimensional images, magnified one million times, reveal in unprecedented detail the structural features of DNA (deoxyribonucleic acid), the large molecule making up the genetic material of all living things. The images also support recent evidence that DNA exists in several different variations of its helically wound shape.

This achievement could open the door to major advances in understanding the structure and function of key biological molecules and the interactions between DNA and proteins. The results also suggest that even higher resolution images can be obtained of nucleotides, the chemical components of DNA.

The images were made through the use of a scanning tunneling microscope, a device that can record structural details of surfaces as small as a single atom.

The team imaged DNA taken from cells in the thymus gland of a calf. Their scanning tunneling microscope is a variation of the device that won the 1986 Nobel Prize in physics for Gerd Binnig and Heinrich Rohrer, of the IBM Research Laboratory in Switzerland. It features a sharp-tipped needle or stylus, made of a platinum-rhodium alloy, attached to a tube of piezoelectric ceramic, a material that expands and contracts in response to an electrical charge. When the needle's tip was brought to within a few angstroms of a sample's surface, a current of electrons crossed the gap via a phenomenon of quantum mechanics known as "tunneling."

FOR ADDITIONAL INFORMATION: Lawrence Berkeley Laboratory; Public Information Department, Lynn Yarris, (415) 486-5375.

# NIST Technology Update

National Institute of Standards & Technology
(Formerly the National Bureau of Standards)
U.S. Department of Commerce, Gaithersburg, MD 20899

## New, Accurate Measurement Made for R-134a

Highly accurate and precise measurements of the vapor pressure and gas phase pressure-volume-temperature relationship for R-134a (1,1,1,2-tetrafluoroethane), a substance with very little published information, have been made by an NIST researcher in the Center for Chemical Engineering. These key measurements in the temperature range 313K to 423K, when combined with other data, should help determine whether R-134a can substitute for specific ozone-depleting chlorofluorocarbon (CFC) refrigerants. Data tables to be published in the International Journal of Thermophysics in early 1989, not only show the experimental precision but also facilitate the calculation of thermodynamic properties

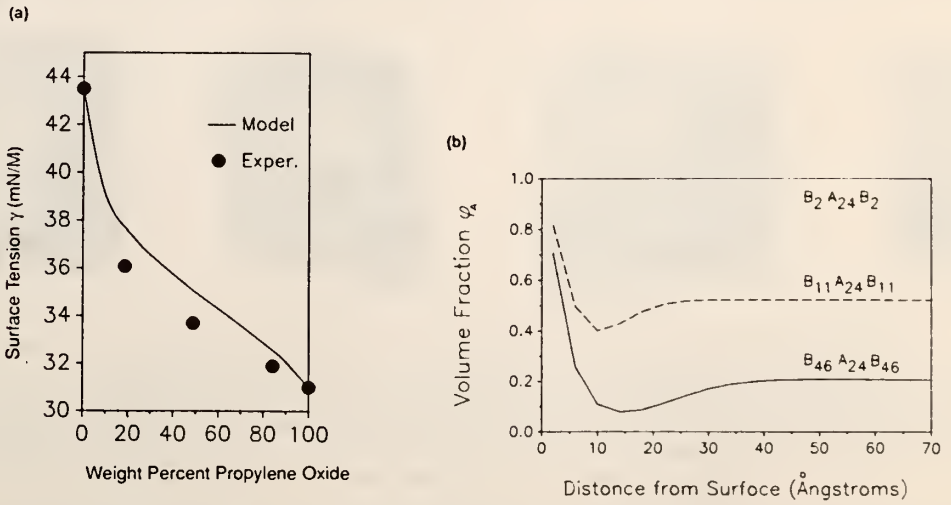
FOR ADDITIONAL INFORMATION: To discuss these efforts further, contact Dr. Lloyd Weber, Physics Building, Room A105, National Institute of Standards & Technology, Gaithersburg, MD 20899; (301) 975-2462.

*Lawrence Berkeley Laboratory*

# Surface Properties of Polymers Predicted by Molecular Modeling

Understanding how the molecular constitution and architecture of polymers affect their interfacial behavior is a prerequisite for efficient materials design in areas such as adhesion, lubrication, industrial melt processing and surface modification to control wetting characteristics.

Polymer researchers at CAM have developed a statistical mechanical model that can predict surface and adhesion tension, and at the same time elucidate local structure at polymer melt surfaces and melt/solid interfaces. Molecular weight and the chemical identity of the monomer units making up a polymer chain are the sole inputs to the model. No adjustable parameters are involved. For homopolymers such as polyethylene and poly(dimethyl siloxane), the chain length and temperature dependence of surface tension are accurately predicted. Moreover, a detailed picture of local density, bond orientation and chain conformation is obtained and used to explain observable surface behavior.




**(a) Theoretical and experimental plots of the variation of surface tension with composition in triblock copolymers of propylene oxide and ethylene oxide.**

**(b) Surface composition of propylene oxide (A) /ethylene oxide (B) copolymers. Calculations predict that while the two monomer units in the copolymer segregate randomly in the bulk, composition of the material near the surface reflects the fact that the monomer with the lower surface tension tends to selectively gravitate towards the surface, while still covalently bound in the polymer.**

The dependence of surface tension on chain architecture in copolymers is also captured successfully. It is shown that the strongly nonlinear variation of surface tension with composition in block copolymers is due to a preferential migration of one of the monomer types to the surface, which is impossible in random copolymers. Predictions of bond orientation in liquids consisting of surface active chains are consistent with NMR data in lipid bilayer membranes. In continuing work, the model is being used to explain intriguing recent experimental evidence on the forces exerted by ultrathin polymer films confined between solid surfaces.

*For Additional Information:*

Office of Research and Technology Application
50A 4112
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Telephone (415) 486-6502

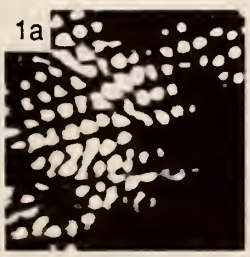
Refer to CAM Volume 2, Number 1/TN

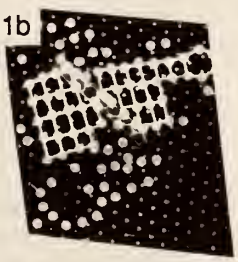
*Lawrence Berkeley Laboratory*

# STM Images Expose Unexpected Atomic Structures of Ultrathin Films

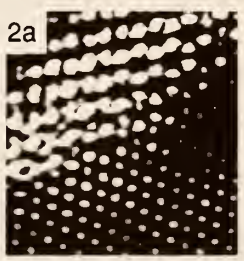
The CAM scanning tunneling microscope (STM), which can directly image individual atoms, has been used to study the distribution and morphology of submonolayer metal films on graphite. Since both the substrate and the overlayer are imaged atom by atom, it is possible to measure with great precision the positions of the adatoms relative to the substrate, as well as the lattice parameters of the overlayer.

Images obtained by CAM investigators John Clarke, Eric Ganz, and Klaus Sattler have revealed a rich variety of unexpected phenomena that illustrate the complexity of deposition and morphology of submonolayer thin films and clusters. The metal atoms were shown for example, to form both small (~40Å diameter) two-dimensional islands and occasional small isolated clusters. The islands show commensurate (adatom lattice aligned in some manner with the lattice of the graphite substrate) and incommensurate phases; breaking of the adatom layer into several locally ordered domains separated by "walls" of disordered atoms (Figure 1); lattice buckling (displacement of atoms above or below their expected linear alignment, Figure 2); rotation of the overlayer relative to the substrate; and surface roughness at the edge of the island where the adatoms stray from the rigorous lattice structure found in the island's interior. Grain boundaries, defects and distortions are also visible.




XBB 879-8305



XBB 879-8306

Figure 1 a) 35Åx 35Å image of part of an island of silver atoms (white spots) deposited on a graphite surface. The island is clearly a monolayer. The underlying graphite honeycomb lattice is visible at the lower right of the image. 1b) Computer enhanced model reconstructed from 1a showing the positions of the adatoms (filled circles) on the honeycomb graphite lattice. Two ordered regions that are incommensurate with the substrate are observed in the interior of the island. The "wall" of disordered atoms between them is indicated by the shaded bar. At the edge of the island the silver atoms are disordered. This is probably because at the edge their interactions with the substrate atoms overwhelm their interaction with other silver atoms.

Figure 2 a) 35Å x 35Å image of a section of a monolayer gold island; 2b) Computer model. At the left of the shaded bar the atoms are in an almost perfect straight chain structure, while on the right the chains are more buckled but not quite in the honeycomb characteristic of the underlying graphite.

In both cases the metal films are prepared *in situ* in ultra high vacuum by evaporation to produce an average coverage of 0.1% of a monolayer. The STM is operated in the current imaging mode in which the tip scans the surface at a constant height and the variations in tunnel current are recorded. Metal adatoms appear as spots of enhanced current. The observed graphite lattice is adjusted onto its known perfect honeycomb lattice, and the adatoms are placed on the model image after undergoing the same transformation.

The lattice structures observed are often quite unexpected and many are as yet unexplained; thus the microscope has opened a new and exciting window to the atomic structure of ultrathin films. Continuing studies are employing the STM to study the morphology, kinetics, nucleation, and growth of these films.

*For Additional Information:*

Office of Research and Technology Application
50A 4112
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Telephone (415) 486-6502

Refer to CAM Volume 2, Number 1/TN

NASA Tech Brief
National Aeronautics and Space Administration
*NASA's Jet Propulsion Laboratory, Pasadena, California*

**Licensing Opportunity**

# Photovoltaic Hydrogen Sensor

The quantum efficiency of a cell decreases in the presence of hydrogen.

A photovoltaic device that senses hydrogen has been developed to test the degradation of diodes that have platinum flash gates (thin platinum coats) on their backs. The sensing element is a p/n junction rather than a conventional Schottky barrier or metal oxide/silicon field-effect transistor. The hydrogen-indicating electrical signal is modulated optically rather than electrically.

The device (see Figure 1) includes a positively doped (p) substrate and a negatively doped (n) front layer. A passivating layer of oxide 20 Å thick is grown on the back, followed by a layer of platinum 10 to 20 Å thick (platinum flash gate). Electrical contacts are made to the p and n regions but not to the platinum. When light is incident on the back surface, most of it passes through the thin Pt and oxide layers and is absorbed in the silicon, where it generates electron/hole pairs. The p/n junction separates the electrons from the holes, and the current collected through the contacts is directly proportional to the absorption of light in the silicon, as in ordinary photovoltaic cells.

Because Pt has a work function that is high in comparison with that of p-type silicon, it creates a region of accumulated positive charge at the back surface. When hydrogen is present at the surface of the platinum, it causes a decrease in the accumulation field at the surface of the silicon, probably by the formation of a dipole layer at the $Pt/SiO_2$ interface. This change in the accumulation field degrades the quantum efficiency of the device, thereby causing a decrease in photocurrent. The amount of decrease depends on, and can therefore be used to indicate, the relative concentrations of hydrogen and oxygen.

As shown in Figure 2, the sensor gradually approaches a steady, decreased value of quantum efficiency about half an hour after the hydrogen atmosphere is introduced. The removal of the hydrogen atmosphere restores the full quantum efficiency in less than 1 minute. The device is most sensitive at a wavelength (about

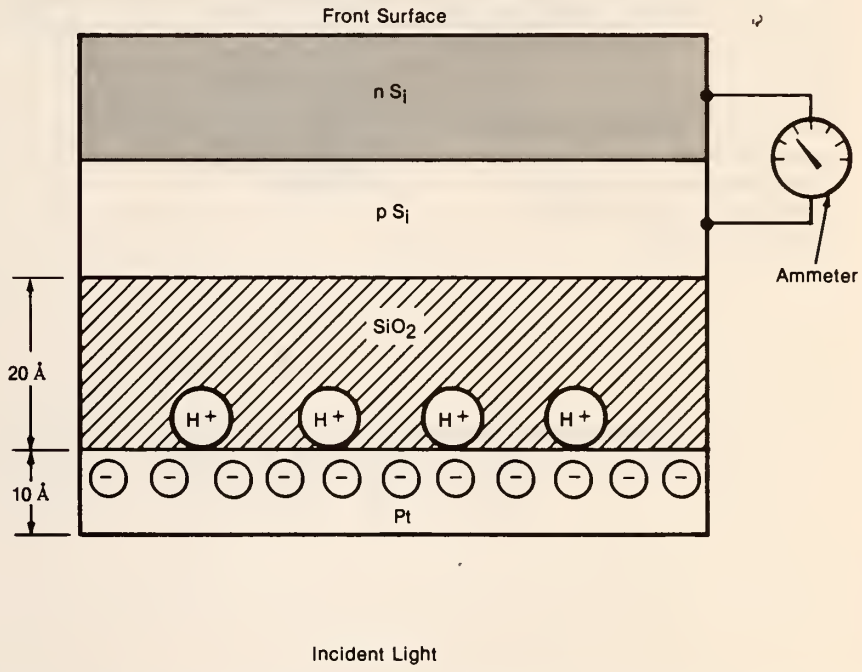



Figure 1. The **Layered Structure of the Hydrogen Detector** and its principle of operation resemble those of a silicon solar photovoltaic cell.

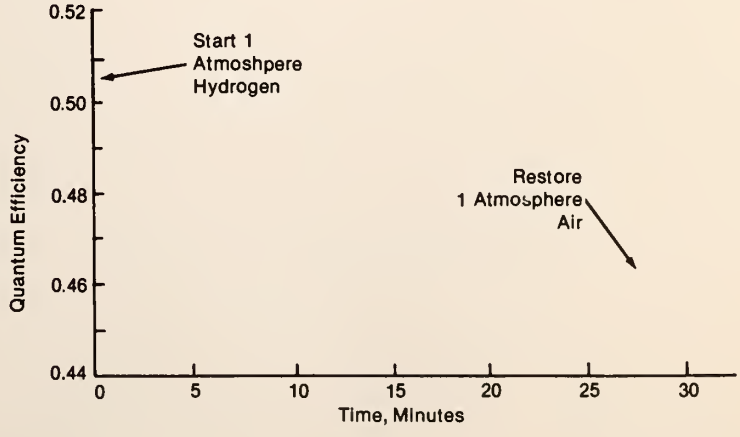



Figure 2. The **Hydrogen Detector Responds** to hydrogen in the atmosphere within minutes and recovers quickly when the hydrogen is removed.

4,000 Å) at which most of the light is absorbed at a depth of a fraction of a micron from the back surface.

*This work was done by Taher Daud, James R. Janesick, and John Lambe of Caltech for* **NASA's Jet Propulsion Laboratory**.

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Edward Ansell,*
*Director of Patents and Licensing*
*Mail Stop 301-6*
*California Institute of Technology*
*1207 East California Boulevard*
*Pasadena, CA 91125*

**Jet Propulsion Lab.**
NASA Resident Office
*Technology Utilization Officer: Gordon S. Chapman*
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4849
*Patent Counsel: Paul F. McCaul*
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2734
*Technology Utilization Mgr. for JPL: Norman L. Chalfin*
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*

REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

# Transportation & Components

0615 Evaluation of Railroad Tracks

0616 Assessment of Semiempirical Dynamic Stall Models for Turboprop Stall Calculations—Three semiempirical models are compared.

0617 Piloted Simulations of a VISTOL Aircraft—Flight and control characteristics are evaluated. (Licensing Opportunity)

# U.S. Army Corps of Engineers
## Waterways Experiment Station
P.O. Box 631, Vicksburg, MS 39181-0631

## Evaluation of Railroad Tracks

The Pavement Systems Division of the Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station, has developed an evaluation program for Army railroads. This four-point program includes visual inspections of the track to locate deviations from Army standards, testing to locate internal rail defects, testing to locate track geometry deviations, and vertical track strength testing to provide a structural evaluation of existing track components and determine the required component sizes.

The evaluation program has been developed so that the different parts of the program can be used independently or in combination to obtain the best and most cost-effective evaluation of an installation's track network. In this program equipment and procedures currently in use by commercial railroads were adapted for use on Army track.

A large part of the Army railroad trackage currently in use through the United States was constructed to meet the logistical demands of World War II, with some of the track constructed before that time. Much of the original construction was surplus material that had been previously used by commercial railroads. Compounding this problem, much of the trackage was intended to handle wheel loads that were about half of the present maximums being applied to the track.

While Army railroad traffic is small by commercial standards, most installations require the track to meet several important missions. These include movement of heavy equipment and supplies, support for training operations, and mobilization readiness. However, funding constraints often result in limited funding for maintenance and repair and lack of trained railroad maintenance personnel. This combination often causes Army railroad installations to be in some undefined state of repair, which may or may not support the loads and traffic required to carry out missions.

The evaluation of an installation's railroad track will assist the installation's facility engineer by providing a sound engineering basis for decisions in the areas of track maintenance planning and track rehabilitation. Transportation and logistics planners can use information from the track evaluation for mission planning, i.e., to judge the adequacy of a particular track for a given mission.

The railroad track evaluation program is currently being used to determine maintenance and rehabilitation requirements. The techniques and procedures are applicable to all types of industrial track, branch lines, and short-line railroads.

FOR ADDITIONAL INFORMATION: For more information about the railroad track evaluation program, write to the U.S. Army Engineer Waterways Experiment Station, Attn: WESGP-IP, P.O. Box 631, Vicksburg, MS 39180-0631, or call 601-634-2223.

NASA Tech Brief
National Aeronautics and Space Administration

# Assessment of Semi-Empirical Dynamic Stall Models for Turboprop Stall Calculations

Three semiempirical models are compared.

A report presents the comparison of stall-flutter responses obtained from three semiempirical dynamic stall models. The study is part of an effort to develop models for the stall-flutter analysis of highly loaded propellers (advanced turboprops).

Under normal conditions, the blade sections of a conventional propeller are at low angles of attack, the flutter speed is high, and generally there is an appreciable margin of safety between the operating speed and the flutter speed. However, during the takeoff period, the blade sections may operate at high angles of attack and could be subjected to stall flutter, a self-sustained vibration in a periodically separated flow. The flutter speed at this condition is very low, and stall flutter affects the fatigue life of the turboprop. Hence, the prediction of the stall flutter speed is critical in design, and an appropriate method of analysis of stall flutter is necessary for research.

The prediction of flutter speeds at low angles of attack (classical flutter) for advanced turboprops has been performed by modifying the existing analysis methods. However, studies of stall flutter have been few and mostly empirical because of the complexity in modeling periodically separated flows.

In the report, the available models of dynamic stall are applied to simple structural models to study the extent of their validity and to select an appropriate model for application to advanced turboprops. Three models of dynamic stall are used together with typical section and plate structural models. The models are compared with respect to their predictions of lift and moment hysteresis loops, predictions of limit cycles, ease of implementation, and the feasibility of developing the corresponding stall models for arbitrary airfoils. A plate model in conjunction with its normal vibrational modes is considered to explore whether the analytical integration of the loads in the spanwise direction is feasible. The numerical study is performed for a single blade, and cascade effects are not included. The analysis of response includes both plunging and pitching motions of the blade.

In model A, a correction is applied to the angle of attack when the angle of attack exceeds the static stall angle. In model B, a synthesis procedure is used for angles of attack above static stall angles, and the effects of history are accounted through the Wagner function. In both models, the lift and moment coefficients for angles of attack below stall are obtained from tabular data for a given Mach number and angle of attack.

In model C, the lift and moment coefficients are given in the form of two differential equations, one for angles below stall and the other for angles above stall. The parameters of these equations are nonlinear functions of the angle of attack. The effects of vortex shedding, an important feature of dynamic stall, are not considered in model A, accurately considered in model B, and approximately considered in model C.

Model C involves fewer parameters than does model B. Model A involves only one empirical parameter but must be tested on advanced turboprop airfoils and on high-frequency, low-amplitude oscillations. The differential form of model C may render it suitable for use in linearized analyses of stability.

One conclusion reached during the study is that the operating environment of an advanced turboprop (high-frequency, low-amplitude oscillations; sweep; and high subsonic speed) favors the conditions of light stall, in which loads induced by vortexes are not severe. Therefore, simple models like A and C can be used to analyze stall flutter and advanced turboprops.

*This work was done by K. R. V. Kaza of* **Lewis Research Center** *and T. S. R. Reddy of the University of Toledo. Further information may be found in NASA TM-88917* Price Code A05 *"A Comparative Study of Some Dynamic Stall Models."*

*Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650.*
*Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-14657/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

**Licensing Opportunity**

## Piloted Simulations of a V/STOL Aircraft

Flight and control characteristics are evaluated.

A report describes simulated flight tests to evaluate the handling qualities and flight characteristics of the Grumman Design 698 aircraft, a vertical and short takeoff and landing (V/STOL) aircraft. The tests were performed by pilots in the vertical motion simulator at Ames Research Center.

The tests showed that a classical control system is adequate for landing on a destroyer in moderate seas and on an aircraft carrier in heavy seas, as well as for the relatively simple task of landing vertically on a fixed pad. The classical control system, based on single-axis control laws, provides individual control of pitch, roll, and yaw with aerodynamic surfaces, vanes, and changes in engine thrust and nacelle tilt. In addition, a modern control system has been designed for the aircraft; it is a direct digital integrated flight-propulsion controller that gives the pilot uncoupled velocity control and attitude control.

Although the simulation pilots had diverse backgrounds, all of them mastered the aircraft with the classical control system. The pilots who had no previous V/STOL experience learned quickly.

According to pilots' ratings and measurements of the performance of the control system, a precision mode of flight control would be needed on a demonstrator or production version of the aircraft. In addition, an unusual characteristic of the aircraft would have to be eliminated: adverse-nonminimum-phase acceleration, in which a negative acceleration is the first result of a pilot's control input.

The two-engine aircraft should incorporate cross-shafting so that a portion of the thrust of one engine can be transferred to the other. Cross-shafting will reduce the recovery speed and the loss of altitude and improve capability for safe ejection of the pilot in cases of engine failure. In either case, during a powered approach the pilot should attempt to maximize the flight time above the minimum recovery speed and above the minimum altitude loss, thus minimizing the flight time below these speed and altitude limits.

*This work was done by Megan A. Eskey and Samuel B. Wilson III of* **Ames Research Center.** *Further information may be found in NASA TM-86785 report "The Handling Qualities and Flight Characteristics of the Grumman Design 698 Simulated Twin-Engine Tilt Nacelle V/STOL Aircraft."*

*Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650.* Price Code A06 *Rush orders may be placed for an extra fee by calling (800) 336-4700.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center*
*Refer to ARC-11807/TN*

**Ames Research Ctr.**
*Technology Utilization Officer: Laurance Miller*
Mail Code 223-3
Moffett Field, CA 94035
(415) 694-4044
*Patent Counsel:*
*Darrell G. Brekke*
Mail Code 200-11
Moffett Field, CA 94035
(415) 694-5104

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Springfield, VA 22161

# NTIS ORDER FORM

*Use this form ONLY to order reports designated as available from NTIS.*

**TELEPHONE ORDERS (703) 487-4650** FAX (Telecopier) (703) 321-8547 TELEX 89-9405

**For Subscription Questions**
**(703) 487-4630**

**For Tracing an Order**
**(703) 487-4660**

**Editorial Questions**
**(703) 487-4805**

**Postage:**
NTIS uses First Class Delivery, or equivalent service, on all shipping. For information about one day RUSH ordering, call (800) 336-4700 or (703) 487-4700.

**NTIS PRICE SCHEDULE ***

This schedule converts into actual prices the price codes cited in those Tech Notes having a report available from NTIS.

| | |
|---|---|
| Microfiche | |
| A01 | $6.95 |
| Paper copy | |
| A02 | 10.95 |
| A03 | 13.95 |
| A04 through A05 | 15.95 |
| A06 through A09 | 21.95 |
| A10 through A13 | 28.95 |
| A14 through A17 | 36.95 |
| A18 through A21 | 42.95 |
| A22 through A25 | 49.95 |
| A99 | Call for price |

These prices are for customers in United States, Canada, and Mexico. Other addresses should write for the price listing, number PR-360-4.

Prices effective January 1, 1989

† Billing Service: There is a $7.50 charge for this service. It is restricted to customers in the United States, Canada, and Mexico. A late payment charge will be applied to all billings more than 30 days overdue.

**If your address lable on this Tech Notes is NOT correct, call the NTIS Subscriptions Department on (703) 487-4630.**

## 1 ADDRESS INFORMATION

Last Name .....

Title .....

Company/Organization .....

Address .....

.....

City/State/ZIP .....

Telephone Number .....

## 2 METHOD OF PAYMENT

☐ Charge my NTIS Deposit Account ..... ..... ..... ..... ..... – .....

☐ Check/Money order enclosed payable to NTIS for $ .....

☐ Please bill **ADD $7.50 per order** (see below for restrictions)†

Purchase order number .....

Charge my ☐ American Express ☐ VISA ☐ MasterCard

Account Number. ..... Exp. .....

Signature .....
(Required to validate order)

## 3 ORDER SELECTION (Use only for reports stated as available from NTIS)

| *NTIS Order Number* | *Price** | *Quantity* | *Total Price* |
|---|---|---|---|
| ...../NAC | ..... | ..... | ..... |
| ...../NAC | ..... | ..... | ..... |
| ...../NAC | ..... | ..... | ..... |
| ...../NAC | ..... | ..... | ..... |
| ...../NAC | ..... | ..... | ..... |
| | | Handling fee | $3.00 |
| | | **Total** | ..... |

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Springfield, VA 22161

# NTIS ORDER FORM

*Use this form ONLY to order reports designated as available from NTIS.*

**TELEPHONE ORDERS (703) 487-4650** FAX (Telecopier) (703) 321-8547 TELEX 89-9405

**For Subscription Questions**
**(703) 487-4630**

**For Tracing an Order**
**(703) 487-4660**

**Editorial Questions**
**(703) 487-4805**

**Postage:**
NTIS uses First Class Delivery, or equivalent service, on all shipping. For information about one day RUSH ordering, call (800) 336-4700 or (703) 487-4700.

**NTIS PRICE SCHEDULE ***

This schedule converts into actual prices the price codes cited in those Tech Notes having a report available from NTIS.

| | |
|---|---|
| Microfiche | |
| A01 | $6.95 |
| Paper copy | |
| A02 | 10.95 |
| A03 | 13.95 |
| A04 through A05 | 15.95 |
| A06 through A09 | 21.95 |
| A10 through A13 | 28.95 |
| A14 through A17 | 36.95 |
| A18 through A21 | 42.95 |
| A22 through A25 | 49.95 |
| A99 | Call for price |

These prices are for customers in United States, Canada, and Mexico. Other addresses should write for the price listing, number PR-360-4.

Prices effective January 1, 1989

† Billing Service: There is a $7.50 charge for this service. It is restricted to customers in the United States, Canada, and Mexico. A late payment charge will be applied to all billings more than 30 days overdue.

**If your address lable on this Tech Notes is NOT correct, call the NTIS Subscriptions Department on (703) 487-4630.**

## 1 ADDRESS INFORMATION

Last Name .....

Title .....

Company/Organization .....

Address .....

.....

City/State/ZIP .....

Telephone Number .....

## 2 METHOD OF PAYMENT

☐ Charge my NTIS Deposit Account ..... ..... ..... ..... ..... – .....

☐ Check/Money order enclosed payable to NTIS for $ .....

☐ Please bill **ADD $7.50 per order** (see below for restrictions)†

Purchase order number .....

Charge my ☐ American Express ☐ VISA ☐ MasterCard

Account Number. ..... Exp. .....

Signature .....
(Required to validate order)

## 3 ORDER SELECTION (Use only for reports stated as available from NTIS)

| *NTIS Order Number* | *Price** | *Quantity* | *Total Price* |
|---|---|---|---|
| ..... /NAC | ..... | ..... | ..... |
| ..... /NAC | ..... | ..... | ..... |
| ..... /NAC | ..... | ..... | ..... |
| ..... /NAC | ..... | ..... | ..... |
| ..... /NAC | ..... | ..... | ..... |
| | Handling fee | | $3.00 |
| | **Total** | | ..... |

- Agriculture & Food
- Computers
- Electrotechnology
- Energy
- Engineering
- Environmental Science & Technology
- Manufacturing, Machinery, & Tools
- Materials
- Medicine & Biology
- Natural Resources Technology & Engineering
- Physical Sciences
- Transportation & Components

## Route To:

PENN STATE UNIVERSITY LIBRARIES
A0000720101O5

EPARTMENT OF COMMERCE
al Technical Information Service
ld, Va. 22161

L BUSINESS
or Private Use, $300

AN EQUAL OPPORTUNITY EMPLOYER

BULK RATE
POSTAGE & FEES PAID
NTIS
Permit No. G-292